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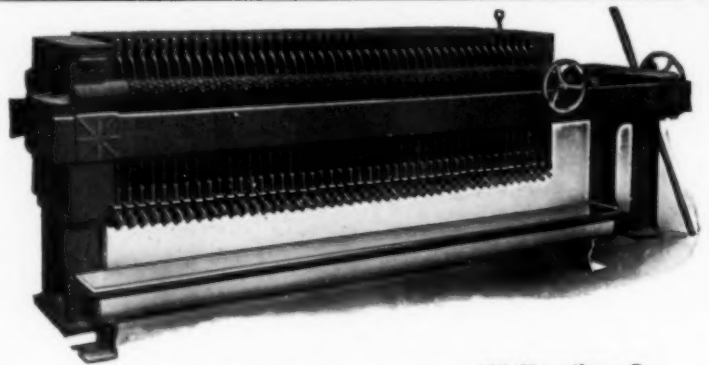
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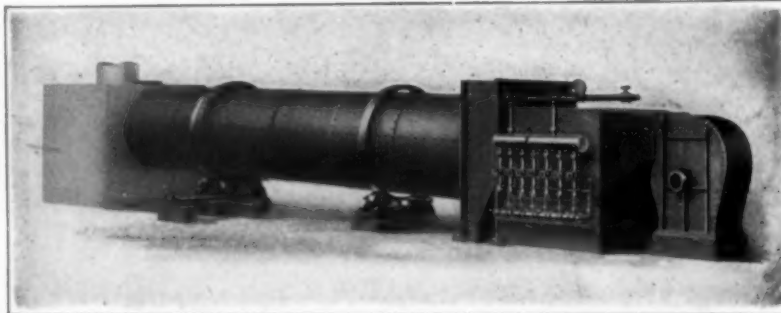
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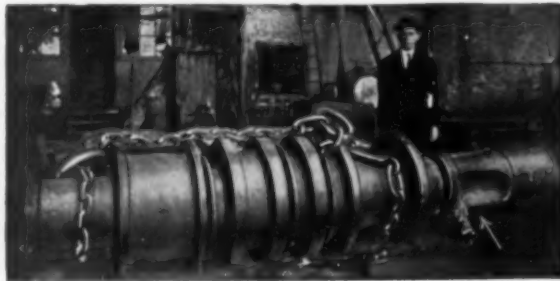


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Metallurgical and Chemical Engineering

A Consolidation of
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Financial and Construction News

In this issue we publish for the first time an industrial news department on pages 546 to 548. The information has been arranged under two headings. Under the first heading "Financial" information is given on newly incorporated chemical and metallurgical companies, changes in capitalization, etc. These items are arranged alphabetically by companies. Under the second heading "Construction and Operation" announcements are included of proposed new plants, additions to present plants, and changes requiring new equipment. These items are arranged alphabetically by states, and by cities in each state. Very little information concerning a company's plans for location of plant can be obtained from the mere incorporation announcement. Consequently this information is arranged alphabetically by companies. Construction news are classified alphabetically by states, as this arrangement not only shows where developments in the chemical and metallurgical field are taking place, but makes it convenient for reference.

Fashion and Style in Chemistry

It is not necessary that a man have a wife and daughters to feel the rod of style or to come under its sway. We have known men whose trousers bagged at the knees, who scorned the nail-brush, who shaved once or twice a week; men of bedribbled waistcoats and lopped coats, who were the slaves of fashion more abject than the fluffiest debutante. Fashions are like faith and include all sorts and conditions of men, while the quality of dress known as "Schneidigkeit" in German and qualified by "chic" in French, is but a minor manifestation. Fashions and styles are of the mind even as they are of the body and its raiment. Hips may be broad in the spring and narrow in the fall or vice versa, and this may become a ruling thought among many women; it may change the design of corsets or bull the market in padding; and yet it is not so far-reaching as a change in the styles of thinking. These are very contagious, and their rule is more severe. Time was when Byron was a great poet, before he suffered his eclipse, and Herbert Spencer, a leader of thought in his day, is now scorned or forgotten. Fifteen years ago the man on the street was wont to buttonhole his acquaintances and urge them to read Benjamin Kidd's Social Evolution, to improve their minds. Kidd died the other day, almost unknown among the world of readers.

Within the past decade or two, a new fashion of teaching chemistry has arisen and we think it timely to consider its effect. Those of us who are old enough to feel the twinges of rheumatism now and then and have

an acquaintance with gout that has lost its humor, recall the grand wedding of chemistry with physics and we were all there, some in mufti and some in wedding garments. It was a grand style-setting affair. At the christening of Physical Chemistry, some of us were not bidden and others have dropped out of the circle of fashion, but they are back-numbers and out of the game. Physical chemistry is the dashing young hero of the day and we must not only recognize him but do homage unto him if we would have recognition among our fellows. This is right, because physical chemistry has a great deal to say. It is a subject of such vast importance that we dare not neglect it. Its philosophy is all-embracing and has to do with the reasons why things happen. The point that we desire to make, however, is that it is also worth while to study what really does happen as well as the reasons why. Here is where the prevailing fashion of crowding into study as much physical chemistry as students can stand, no matter what the subject may be and as often as there is a chance, may cause the chemical aspirant to miss a thing or two. Reactions still take place, whether they are explained or not, and it is worth while for the chemist to know what they are. They are facts, often baffling facts, and yet they are persistent. It seems to us that they should be learned, learned by heart, so that the young chemist may know them. The reasons why are of vast importance and the search for them whets our curiosity, without which we are of no avail in research. But chemistry has to do on the whole with the ways of stuff and these must be known no matter why they happen. Explanations come after a fact as well as before it, and this is why we believe in drilling in the reactions rather more thoroughly than is the tendency to-day. We should be the last on earth to decry the value and use of physical chemistry; we are merely raising our voice against the neglect of reactions.

Let us consider a few examples in fancy to make our contention clear. Suppose the elements were families or corporations and had to look out for their reputations. The passion for self-justification among families, corporations, and, indeed, among all of us, is such that we always contend that we are misunderstood when we lose standing among our fellows. Now if tin were a corporation as we have suggested, then it would need the Hon. Elihu Root of New York and Mr. John G. Johnson of Philadelphia to plead for the integrity of its purpose, while to keep it out of limbo on charges of totally unwarranted perversion of the laws of more bid-dable elements, it would need Messrs. Samuel Untermyer, John B. Stanchfield and Abe Levy. With this imposing array of counsel, we should be persuaded of everything they wanted us to believe about tin, but would we really understand it? Would we have the truth, which is all the facts about it in their right relation, in our minds? What would we know about tin when these learned gentlemen had finished with us? Counsellor Levy would have thrown out all evidence of its irregular ways on the ground that the testimony was incompetent, irrelevant and immaterial. Counsellor Stanchfield would have carried us away with his elo-

quence over its silvery beauty. At about this point we should learn that our rich uncle who is growing old and a little uncertain as to how he will leave his money is firm in the opinion that those whipper-snappers that question the regularity of the behavior of tin are a lot of ignorant blatherskites. Mr. Untermyer would persuade us that the whole rumpus about it was a stock-jobbing trick that originated in Wall Street and he would give us the number of the Street and the name of the firm responsible for the iniquitous calumny. Messrs. Root and Johnson would demonstrate the elemental nature of tin and leave us self-respecting and convinced that it is innocent of all allotropy and that its behavior is, in effect, the standard of all metals; that in whatever measure metals differ from tin in their reactions, in so far as they, not tin, are irregular.

It would be a delightful entertainment, but it would not fit us for work with tin. The analogy that we are trying to indicate is that while physical chemists do earnestly seek the truth, they haven't gathered in all the facts yet and we need a lot of facts which they have not collected.

Nothing is so sorely needed in general culture to-day as chemical philosophy. It teaches the larger laws than those writ upon the statute books, the need of correlation, and the inevitability of consequences. But young chemical engineers should know reactions better, know them as the multiplication table; have them in the backs of their heads and be in a position to draw upon memory for them. It does the historian of Early America no harm to know that Columbus landed in 1492. He does not deduct the date from his knowledge of contemporary tendencies and spirit of adventure; he boned for it and learned it. And that is the only convenient way to learn of a great many reactions.

"It Can Be Done"

In many offices there has lately been hung a motto "It can be done!" The times are so strenuous that men hardly have time to notice the motto, but the suggestion embodied is being carried out. Under pressure of the unprecedented conditions existing men are doing things that before the war would have been regarded as impossible. This is the case both with steel producers and with steel consumers. Steel producers have found that ferromanganese is not the *sine qua non* it was once considered. Special grades of steel are made at mills whose mission was supposed to be the manufacture of ordinary soft steel exclusively. Departments are being operated with fewer men than was supposed to be necessary.

Steel consumers who felt that they must have a certain description of steel have had the choice of some other description of steel—or nothing, and they have not selected the nothing. The votaries of open-hearth steel have accepted Bessemer. Those who had to have soft steel have chosen carbon steel, the now so familiar "shell billet discards" rather than nothing and have found they were able to get along with it. Machine shops have trained common labor to do lathe work on shell parts with an accuracy they doubted could be compassed with their most experienced machinists.

Volumes could undoubtedly be written of the new things men have done in the steel trade and its allied industries, if the men who have done them had the time to write, but that is precisely what they do not have.

If in the United States unusual things have been done, still more remarkable must be the things that have been accomplished abroad in the countries at war. The English and French came to us with demand that we roll steel rounds for shells, and were disappointed at the deliveries received. When Italy entered the war the United States was combed over for old steel locomotive and car axles, to be converted to the same use, with the result that the last sales have been at almost double the regular consumer would care to pay. And some marvelous things which Germany has done—notably in connection with nitric acid—have been recorded from time to time in these pages.

Export and Domestic Steel Demand

Early in the present period of steel trade activity there was a belief in many quarters that the activity was produced chiefly by an export demand. That notion no longer obtains, as the facts are now well apprehended. Still, it is desirable to lay down the measuring rod occasionally upon the latest statistics available in order to observe the precise relation between domestic and export demand. In the magnitude of the domestic demand thus disclosed there are certain indications as to what is to be expected when the war ends.

The government's export statistics classify under the heading "iron and steel" all commodities that are really such, including scrap, pig iron, unfinished steel, rolled steel, wire products, pipe, machinery, hardware, cutlery, etc. Outside this classification are various manufactures in the production of which iron and steel enter, such as electrical machinery, agricultural machinery, automobiles and railway rolling stock except locomotives, as locomotives are placed under iron and steel. The proportion of iron and steel exports to total exports has been as follows:

	Per cent
1912	12.0
1913	11.8
1914	9.5
1915	10.9
August, 1916	16.9

The value of iron and steel exports is large, \$86,296,703 last August, but the exports of all merchandise are extremely large, \$509,894,479 in August, almost two and one-half times the average monthly exports in the record calendar year before the war. The increase in the proportion of iron and steel from 1912 to 1913 to August of this year is only 42 per cent. There are many commodities the proportion of which has increased much more.

Doubtless the values per unit of quantity have increased much more in iron and steel than in merchandise generally, as in the domestic market the common steel products have more than doubled in value since the low level of December, 1914, while the present values

are nearly double the average market values of 1912 and 1913. Another method of comparison is to ascertain the relation between the production of pig iron and the weight of the iron and steel products exported that are returned by weight. In 1912, the year of largest iron and steel exports before the war the weight of iron and steel exports was 2,948,466 gross tons, which represented 10 per cent of the 29,726,937 tons of pig iron produced in that year. In the first eight months of this year the exports amounted to about 3,710,000 tons, while the concurrent pig iron production was about 26,100,000 tons, showing a proportion of 14.2 per cent. It is interesting to observe that this comparison, on a totally different basis, shows precisely the same increase in the proportion, 42 per cent, as is shown by comparing the value of iron and steel exports with the value of all exports.

The exports of merchandise in the manufacture of which iron and steel is consumed but which is returned under categories other than iron and steel, have increased quite sharply, but the total value is not large as compared with iron and steel, nor is the quantity large as compared with the domestic production. Thus in the first eight months of this year 56,599 automobiles were exported, valued at \$64,640,068, but the number exported was only about 6 per cent of the number produced. A comparison of values would probably show a slightly higher proportion.

The comparison by using the total weight of iron and steel exports may be objected to on the ground that the total includes such widely different commodities as pig iron and billets on the one hand and wire nails and boiler tubes on the other, but the more one studies the statistics the more fully he realizes that after all iron is iron despite the facts that the open-hearth furnace receives pig iron and scrap and the steel rolling mill delivers a much smaller tonnage of rolled steel than it receives of ingots. It is illuminating therefore to make a comparison by deducting the weight of iron and steel exports from the pig iron production. For the year 1913, the year of largest domestic demand before the war, the remainder is 28,235,000 gross tons. For the first eight months of this year the remainder is 22,400,000 tons, or at the rate of 33,600,000 tons, suggesting an increase in domestic demand of 19 per cent in three years. The actual increase is less, but not much less. The showing is distorted somewhat by there being more iron and steel than formerly involved in exports which do not enter the tonnage category.

This large domestic demand is occasioned by the general industrial activity, and some of that activity is directly produced by the war demand for commodities other than iron and steel, but a great deal of the activity is caused by the country having been made rich. The wealth will remain after the war, at least in large part. At the present time a great deal of it is undistributed. Funds are being held because it is physically impossible to invest them or because their holders desire to await the more settled times that will follow the war. Eventual investment will necessarily occur and that will occasion a new demand for steel.

Readers' Views and Comments

The Electrolysis of Cryolite-Magnesium Oxide Mixture

To the Editor of *Metallurgical & Chemical Engineering*

SIR:—From analogy with the fact that aluminium is made by the electrolysis of aluminium oxide dissolved in melted cryolite, it might appear probable that if magnesium oxide were substituted for aluminium oxide, magnesium would be deposited at the cathode in place of aluminium. This conclusion, however, is not theoretically correct. In the mixture of magnesium oxide and cryolite the following ions exist, (possibly also more complex ions): Na^+ , Mg^{++} , Al^{+++} , F^- , and O^{--} . On electrolysis, those ions would be liberated whose decomposition voltage is the least. In this case, these are the aluminium and oxygen ions.¹ Therefore the products of the electrolysis of cryolite-magnesium oxide mixture should be the same as those of the electrolysis of cryolite-aluminium oxide mixture. As the electrolysis proceeds, with the removal of aluminium and oxygen, aluminium oxide would have to be added to keep the composition of the bath constant.

This is similar to the case of aqueous solutions of ions whose decomposition voltages are higher than those of hydrogen and oxygen ions, for example, sodium fluoride. When a solution of sodium fluoride is electrolyzed, hydrogen is liberated at the cathode and oxygen at the anode, and the only function of the sodium and fluorine ions is to carry the current through the solution. The most easily deposited ions then carry it from the solution to the electrodes.

The following experiment proves the correctness of the above conclusion.

A graphite crucible of 4 in. inside diameter was used as the cathode of an electrolytic cell. The anode was a 2-in. graphite rod. A mixture of ten parts of cryolite to one of magnesium oxide was melted and electrolyzed with from 6 to 8 volts and from 150 to 200 amp. The anode effect², frequently interfered with the electrolysis. After the cell cooled off it was broken open and pieces of metal were found which were easily recognized as consisting principally of aluminium. There were other smaller pieces of metal which had the appearance of silicon and which were probably silicon aluminium alloy. Counting all metal obtained to aluminium the current efficiency was about 20 per cent. There was no odor of fluorine, and the mixture of cryolite and magnesium oxide has three to four times the conductivity of cryolite alone.

M. DEKAY THOMPSON.

Massachusetts Institute of Technology,
Cambridge, Mass.

Dielectric Constants and Flotation Values of Oils

To the Editor of *Metallurgical & Chemical Engineering*

SIR:—The following results of some experiments undertaken to see what relation, if any, existed between the dielectric constant and the flotation values of various oils, may prove interesting.

The dielectric constants were determined by Dr. Herman Schlundt of the University of Missouri and the flotation values by Charles Y. Clayton and C. E. Peterson of the Missouri School of Mines at Rolla, Missouri.

¹It is here assumed that none of the ions are so dilute as to change their relative positions in the electrochemical series.
²*Electrochem. and Met. Ind.*, 7, 19 (1909).

Oil	Behavior in Flotation	Flo. Value	Prelim. Dielectric Constant Approx.
Citronella.....	Frothing, giving an ephemeral small bubble froth.	30.0-74	4.38-4.83
Orange peel.....	Thick pulpy froth.	21.0-76	2.0-2.33
Pine oil.....	Frothing, giving an ephemeral small bubble froth.	16.0-69	4.42
Lemon oil.....	Frothing, giving an ephemeral thin froth.	25.0-68	2.95
Cresylic acid.....	Frothing, giving a more lasting large bubble froth.	32.0-71	9.80
G. N. S. No. 8.....	Frothing, giving large stiff bubbles.	32.0-61	4.36 hydrox.
G. N. S. No. 17.....	Frothing, giving large thin bubbles.	32.0-75	12.0 hydrox.
G. N. S. No. 18.....	As above.	35.0-71	9.8 hydrox.
G. N. S. No. 22.....	Frothing, giving medium sized ephemeral bubbles.	19.0-68	3.05
1/2 cresylic, 1/2 castor oil.....	Non-frothing, giving a heavy skum of small bubbles.	24.0-73	4.33 conducts
Peach kernel.....	Frothing, small bubbles.	7.0-54	2.86
Castor.....	Non-frothing, skum like.	20.0-52	3.40
Crude wood turpentine.....	Frothing, giving an ephemeral small bubble froth.	5.0-61	4.15
Olive oil.....	Slight skum formed.	3.0-54	2.76
Cottonseed.....	Small amount of slight bubbles.	5.0-67	3.00-2.71
Corn oil.....	Practically inactive.	No	3.00-2.6
Soya bean oil.....	Practically inactive.	No	2.96
Rosin oil.....	Heavy stiff froth.	22.0-37	2.95
Black grease.....	Frothing, giving large stiff bubbles.	16.0-23	3.12-2.78
Oleic acid.....	Frothing, giving large stiff bubbles.	77-13	2.7-2.35
Sperm oil.....	Thin film formed.	4.0-55	2.90
Cod liver oil.....	Thin film formed.	3.0-58	2.85
Lubricating oil.....	Thin film formed.	1.0-22	2.6-2.15
Crude petroleum.....	Thin film formed.	3.0-36	2.28
Water gas tar.....	Inactive, failed to emulsify.	No	2.78
Coal tar.....	Inactive, failed to emulsify.	No	3.49

The flotation tests were made in a modified Hoover machine, the capacity of which was 4000 grams of water and 800 grams of ore. The impeller gave 1700 r.p.m.

The ore used was a dolomitic lead ore crushed to pass 80 mesh.

The only variable throughout these tests was the kind of oil.

The behavior of the oil under test was observed and its flotation value calculated. The flotation value is defined as the weight of concentrate and the metal content obtained in a run of 20 minutes. For example, oil of citronella has a flotation value of 30.0-74, which means that in a 20-minute run 30.0 grams of concentrate was obtained, which analyzed 74 per cent lead. No attempt was made to determine the total extraction, the idea being to get relative results under the same conditions.

The above data indicates that of the oils tested those with a high dielectric constant gave the best results. Oil of orange peel and oil of lemon are exceptions to this statement.

CHARLES Y. CLAYTON.

Missouri School of Mines and Metallurgy,
Rolla, Mo.

Coming Meetings and Events

Joint meeting of N. Y. Section American Electrochemical Society and Illuminating Engineering Society, Engineering Societies Building, New York, Nov. 9.

American Mining Congress, Hotel LaSalle, Chicago, Nov. 13-18.

American Society of Mechanical Engineers, New York, Dec. 5-8.

American Association for the Advancement of Science meets with American Chemical Society and also with the four national engineering societies represented at the Engineering Societies Building, New York, Christmas week, 1916.

American Institute of Chemical Engineers, New York, Jan. 10-13, 1917.

Revision of Chemical Statistics

Joint Meeting of New York Sections of American Chemical Society, American Electrochemical Society and Society of Chemical Industry

The first meeting of the season of the New York Section of the American Chemical Society was held jointly with the New York sections of the American Electrochemical Society and the Society of Chemical Industry in Rumford Hall, Chemists' Club, Friday evening, Oct. 13. The subject under discussion was "Revision of Our Chemical Statistics." Dr. J. MERRITT MATTHEWS, chairman of the New York Section of the American Chemical Society, presided. It being the first meeting of the season the chairman gave a short address in which he discussed several aspects of pure and applied chemistry and their relation to the society and the public.

He said there is a growing tendency to take up technical chemistry in the American Chemical Society, to a greater extent than heretofore. To the layman the study of pure science is but a useless occupation and unless of immediate practical benefit it is considered to be of no value. Discussing the advancement of chemistry, Dr. Matthews said that on one hand we have pure science being worked out in the laboratory with no thought of practical application. He questioned whether this did not seem a little out of the sphere of human interest. On the other hand, pure science is essentially a science of culture, furnishing excellent mind training and in this respect it is all important. He cited the example of Galvani's study of the twitching of the frog's legs which years later led to the great discoveries of electricity. There is not a fact or theory which is developed which does not help some one in some measure. Dr. Matthews thought we are apt to depreciate pure science, in the present age of commercialism. Specialized knowledge in one branch of industry is the main thing at present. Our motto is becoming "It pays to know." He said we are realizing a greater dignity for science as a profession and not as a mere diversion. In the past two years there has been a better appreciation by the press and public, but there is still the idea that chemistry is a hodge podge of mysterious ideas. Chemistry is, however, becoming more and more a part of our human life, and the public interest shown during the recent exposition was very encouraging.

Following Dr. Matthews' address the report of the Press and Publicity Committee appointed for the recent New York meeting was read by Dr. Allen Rogers, chairman of the committee. This committee did a large amount of publicity work in connection with the New York meeting during the recent Exposition week. An office was maintained at the Chemists' Club at which an average of twenty reporters called daily. By making use of a clipping bureau material which was published was clipped out and sent to the committee. About 1000 clippings were returned from 290 newspapers in 164 cities and 41 states. After the reading of the above report Dr. Berolzheimer and Dr. Bogert expressed great appreciation of the work done by this Publicity Committee.

In the line of general business Dr. Hesse introduced a motion that the executive committee be requested to examine into the desirability of a closer coördination of the various sections of the Chemical Society on questions of public interest. He said that in the case of the recent dyestuff tariff, many people were of the opinion that the recommendations made by the New York Section were representative of the whole society. The motion was passed.

A committee consisting of Messrs. Whitaker, Metzger, and Berolzheimer was appointed by the chairman to assist with the work on chemical statistics. He also made the announcement that the suggestion had been made to establish an exhibit of new products made in this country since the war began, at the American Museum of Natural History. Any one having any products to exhibit should bring them to the attention of Drs. Fink, Alexander or Matthews, the respective chairmen of the New York Sections of the American Electrochemical Society, Society of Chemical Industry and American Chemical Society.

The paper of the evening, "The Revision of Our Chemical Statistics," was then read by Dr. Bernard C. Hesse. This is printed in full elsewhere in this issue.

The discussion was opened by Dr. Matthews, who said that one obstacle which presented itself was the narrow-minded attitude of the chemist. He said statistics form the basis of further expansion of our chemical industries, and anyone who has been interested during the past two years in the development of new products has encountered the difficulty of obtaining accurate statistics as to the amount imported and consumed.

Dr. Bogert thought the national committee on industrial preparedness of the Naval Consulting Board ought to be able to help the committee on statistics of which Dr. Hesse is chairman. The National Research Council could also help.

In reply to a question as to how the foreign lists were made up Dr. Hesse said as a rule they try to tell themselves as much as possible about their own business and tell the other fellow as little as possible. For this reason export statistics are not so finely divided as import statistics.

Dr. Herman A. Metz said that statistics were a fine thing and were badly needed and that the colors should be grouped under various headings. He said if these statistics had been available, many who went into the dye industry would have stayed out when they found out how little was really used. He was strongly opposed to publishing the importer's name with the statistics, as he said the amount imported by each firm and the price they pay are "stock in trade" and should not be given out.

Dr. H. A. Huston of the German Kali Works thought discretion should be used in publishing the reports, in order to get the confidence of the importers. He said that government statistics as furnished at present often do not agree with the importers' statistics. The matter of revision should be taken up through the subcommittees of the House and Senate furnishing these subcommittees with accurate technical advice. He said that his company had been very liberal in furnishing statistics and that many inquiries had been made. An interesting part of his discussion dealt with the report of the Federal Trade Commission on the fertilizer industry. He said if the statistics contemplated were going to be anything like that it would dampen everyone's enthusiasm for statistics. This report analyzed the fertilizer industry, discussing the companies in succession and giving all the inside details of each company's operations.

Mr. Metz said that in the recent shipment of dyes to this country on the submarine, Germany didn't publish detailed statistics as to how much each company received. Totals only were given out.

Dr. Alexander said that domestic statistics should be published to complement the import statistics.

Dr. Hesse thought it was too big a job to tackle at one time and that efforts should be concentrated at first on obtaining adequate import statistics, then exports could be taken up, then domestic statistics.

The Iron and Steel Market

October has been a strenuous month in the iron and steel markets. The increased activity that became perceptible early in August in both pig iron and steel products, and was somewhat accentuated in the second half of September, has reached proportions not altogether incomparable with the extreme activity of the late months of last year and the early months of this year. The unprecedented has occurred. After a period of practically stationary prices in both pig iron and steel fresh and important advances are occurring. In all the history of the trade there had been so such performance. Upward market movements have always been separated by periods of market stagnation and great price declines.

Using a weighted average for the common steel products, bars, plates, shapes, wire, pipe, sheets and tin plate, a sketch may be made of the steel movement from the low point at the end of 1914 to the present time. In the first nine months of 1915 there was an advance of about \$5 a ton, while the advance in the last three months was no less than \$8. In the first three months of this year the advance was fully \$12 a ton, this period representing the culmination of the general movement. In the next six months advances averaged less than \$1 per ton per month, but October has shown advances of fully \$3 a ton. So involved has the situation become, however, that price comparisons that could be made with confidence earlier in this movement must now involve assumptions, almost guesses, because the pressure for material is so great and the mills are so burdened with orders that the market is not clearly defined. In many cases they name certain prices as representing their view of "the market" but when offered an order at the price they decline to accept.

The Course of Pig Iron

Using a weighted average to represent the different descriptions of pig iron in different markets, one starts with a low point at the end of 1914, but not until late in July, 1915, was there any general disposition in the market to advance. In the closing months of the year there was a total advance of about \$4.50. Slight advances and subsequent declines left it that at the close of August prices were not higher than at the opening of the year. Now, much the same as in 1915, an advance is in progress, carrying prices up more than 50 cents a ton in September and more than \$2 a ton in October. The course the pig iron market followed in 1915 is readily explained. Demand was increasing steadily during the first half of the year, but idle furnaces were continually being blown in whereby increased demand was met at each successive point by increased supply. Finally, as the less fit furnaces were brought into blast, with higher costs, the market responded to further increases in demand. This year, with prices quite profitable and furnaces tempted continually to sell far ahead, the market lacked a definite force to advance it, until in the past two months there arose fear that an actual shortage might be developed. As the buyers, or at least the steel works, are financially able to pay almost any price for pig iron there has been nothing to hold prices down once the furnacemen acquired the habit of advancing their quotations. Whether or not a shortage will develop cannot be predicted, but some signs have appeared in the past fortnight of there being a scarcity of spot iron.

The Steel Mill Attitude

The steel mills expect the war to last another twelve-month. In the past two or three weeks they have received additional orders for shell steel both for early

delivery and for delivery to the middle of next year, while at the same time inquiry has begun to appear for second half deliveries. With the business that must be carried over from this year because the mills are behind in deliveries the large mills and many of the small mills are obligated for a tonnage almost equal to their production to the middle of next year, this statement referring to the general average, while as some commodities are never sold very far ahead there are others in which the obligations would carry the mills almost through 1917.

The attitude of the mills has been to take care of their regular customers as well as possible, by giving them contracts, subject to specification in future, but by this time such protection has been given in nearly all instances for as great a distance ahead as it is considered desirable to sell. Many of these contracts are accepted with the understanding that in case of a decline in the market, as in the event of the war ending, the buyer will be protected. The contract business is nearly all done, for the time being, while there remains a large demand for steel for specific jobs, in ship and car building, etc. The mills are willing, of course, to accept orders for delivery any distance ahead provided it is assured that the material will be taken irrespective of market conditions. As there is no occasion to protect buyers who are not regular customers the disposition is to advance prices. The mill attitude is much the same as that occupied early this year, when it was not expected that there would be much more buying and the mills advanced prices in the expectation that thereby their order books would eventually be cleared. The outcome was otherwise, and such may be the case again, but the common view of producers probably is that this wonderful movement in steel will come to an end about a twelvemonth hence, and then will follow the extremely drastic readjustment that has been recognized all along as unavoidable.

Non-Ferrous Metal Market

Oct. 26.—There has been comparatively little change in copper prices during the last two weeks, the market being quiet but firm. Lead is unchanged but the market has been more active. Spelter has advanced on a larger demand and tin has also advanced, although the market has been quiet.

Copper.—The copper market has been very quiet but prices hold very firm. Second hands are offering but small amounts for delivery during the balance of the year. The large producers are doing business for the first half of 1917. Lake copper for November and December delivery is quoted at 28½ cents, with electrolytic at 28½ cents for prompt and November and 28 cents for December. January and first quarter electrolytic is 26½ to 27 cents, while second quarter is offered at 26½ to 27 cents. Exports in tons of 2240 pounds up to Oct. 24 were 21,681 tons.

Tin.—Business in tin has been generally dull during the past two weeks, although the market is strong, and prices have advanced ½ cent to 41.70 for prompt deliveries. So far this month only 2005 tons has been received from foreign sources, and there is an increasing difficulty in getting shipping permits from England, who practically controls the shipping situation. This grip could be tightened at any time and the shortage would be keenly felt here. The advisability of carrying large stocks is apparent. Some authorities predict higher prices for next year and also expect England to place an export duty on tin. Prompt Straits is quoted at 41.70 cents, with futures at a slightly higher figure. Speculation in tin in England has practically ceased.

Lead.—The lead market is very strong and the demand is heavy, although the buying has not been exceptionally active during the past two weeks. This is probably due to the sold up condition of the market. The New York quotation by the trust is still 7.00 cents, with independents asking 7.00 to 7.12½ cents. Chemical lead is in excellent demand and considerable of it has been purchased lately. Exports so far this month have been 2817 tons.

Spelter.—A fair business has been done in spelter during the past two weeks and the market is stronger with prices higher during the last few days. Producers are not offering any great amount in spite of the good demand especially noticeable on Oct. 23, when the market was flooded with inquiries from the galvanizing trade. Prompt spelter is quoted at 10.17½ to 10.42½ New York and 10.00 to 10.25 East St. Louis. Exports so far this month are 7027 long tons.

Other Metals.—*Aluminium* is quoted at 64 to 66c. for No. 1 virgin metal. *Antimony* is quiet after a three weeks period of buying by Canadian interests, which stimulated the market and advanced prices. Prompt Chinese and Japanese is quoted at 13.25 cents. *Magnesium*, 99 per cent is held at \$3.50 per lb., and electrolytic nickel at 50 cents. *Cadmium* is quoted at \$1.50 per lb., *quicksilver* at \$80 per flask, *platinum* at \$90 per oz., *cobalt* at \$1.25 per lb. and *silver* at 67¾.

The Western Metallurgical Field

Mills

Within the next sixty days the plant of the **Tintic Milling Company** at Silver City, Utah, will be brought up to its capacity of 300 tons per day. The mill at the present time is handling eighty-five tons per day. Eight new Holt-Dern roasters will be installed of which six have arrived at the property, the other two arriving in the near future. This will materially decrease the cost of production and metallurgists, which have visited the mill, claim that the problem of treatment of the low-grade, siliceous, copper-silver ores of the Tintic district has been solved at this plant.

The number of mills of the Porcupine District, Canada, will be increased in the near future by the new mill of the **Foley-O'Brien**. The management at the present time is considering the plans for the mill, the foundation of which will be laid before winter. The mill capacity will be 150 to 200 tons per day. Both stamps and mills are being considered.

Recovering Values in Big Mine Dumps

The problem of recovering the values from extensive and old mine dumps is becoming of more and more interest in the field of metallurgy. This is due to the fact that rich ores are becoming more scarce and as some of the old dumps carry as much or more values as the low-grade ores treated, the solving of this problem is of paramount interest.

At Georgetown, Col., a testing plant is in operation running tests on the dump of the **Colorado Central**. Detailed results are not available as yet, but one of the main features is the hand sorting of the material down to one inch in size. The test mill uses a Dodge crusher, trommels, pocket feeders, one to five compartment jig, three Wilfley tables, three Richards pulsator classifiers, one Deister table for the slimes and a flotation machine. According to an authority the experimental work is progressing satisfactorily and a mill will be in operation in the near future. The dump contains 300,000 tons of low-grade lead, copper, silver ore.

Experiments on the dump of the property of the **Colorado-Utah Mines Company** at Lake City, Col., have shown that the dump can be economically treated. The dump contains about 75,000 tons of material. The values of the fills in the old stopes can also be recovered. The management has decided to install finer grinding machinery and recover the values by flotation. This will increase the tonnage treated per day. The present-day practice is to concentrate the ore on tables and to treat the table fines by flotation. The table concentrates run 0.5 per cent copper, 8.6 per cent lead, 47 ounces of silver and 1.4 ounces of gold per ton of concentrates. There are two grades of flotation concentrates, one running 1.65 per cent copper, 2.3 per cent lead, 38.2 ounces silver and 0.57 of an ounce of gold; the other carries 7.3 per cent copper, 21 per cent lead, 81.32 ounces of silver and 1.68 ounces gold per ton of concentrates.

The Hill City Tungsten Production Plant

On Sept. 1, the **Hill City Tungsten Production Company** at Hill City, S. D., started taking custom ores. This mill is the largest one built up to date, the Clark mill at Boulder, Col., being the second largest. The Clark mill handles 75 tons per day, while the Hill City plant treats 150 tons. The power plant consists of two 100-hp. boilers equipped with automatic stokers for burning slacked coal. All the machinery is electrically driven, both at the mine and at the mill by a 90-k.w. generator.

The ore is delivered into a 1000-ton storage bin by the C. B. & Q. Railroad; from here the ore passes to the head bin in the mill. The ore is reduced in three steps: first in a jaw crusher; second by a 30x14-inch roll. Screens are used between the crushing apparatus to remove ore which needs no further reduction. The ore then passes through a Vezin sampler, which takes 1-100 cut for assay. The reject is conveyed by means of a 60-ft. conveyor to a 150-ton storage bin. This bin is located above the concentrating room and holds enough ore for one day's run, so that the mill will not be shut down if any repairing has to be done in the crushing department. By means of an automatic feed the ore is conducted to a pneumatic jig, which removes the coarse mica before the ore is wetted. This latter arrangement solves the troublesome mica problem, which previous to this time made the working of the ores difficult.

From the pneumatic jig the ore passes through eight sizing screens. First, the material passes through revolving trommels; second, a duplex Callow screen; third, through duplicate Bunker Hill screens, and finally through a Callow cone classifier. This combination is probably the most elaborate screening system used. It was decided on this method after three months' trial at the mill of the **Black Hills Tungsten Mining Company** at Hill City.

The secret of high recovery of tungsten lies in the treatment of the middlings. Experimental work has shown that close sizing only would avail. The ore therefore is divided into the following sizes necessitating the passing through rings 3-5, 5-8, 8-16, 16-24, 24-40, 40-80, 80-200 and through 200. The first two go to two jigs; the third to the sixth, inclusive to Wilfley tables; the seventh to a Deister-Overstrom slimer and the eighth to the flotation plant. The middlings from the first three are reduced to 29 mesh in a 14 x 30 roll; those of the fourth to the sixth inclusive are reduced to 80 mesh in a National disc pulverizer and the middlings from the remainder are reduced to size in a 4½-foot ball mill. All the re-

ground products are pumped back on the duplex Cal-low screens, where they are again sized and sent to the tables with the original ore stream.

The treatment of the middlings consists in taking a large portion from the finer tables and treating it in a flotation plant, and on canvas, 1080 ft. of which has been installed.

The mill is adaptable to any type of custom ore. The three regrinding units have been installed so as to take care of any middling problem which may occur. They will be used on refractory ores only.

The outstanding features showing the high efficiency obtained are close sizing with duplicate screens below 16 mesh to prevent stops for repairs, the regrinding system with duplicate pumps, etc., the treatment of tails by flotation and canvas and the use of three-coarse crushing units, with intermediate screens to prevent sliming.

Company Reports

The annual report of the **Temiskaming Mining Company** for the year 1915, ending with December 31, shows the treatment of 26,927 tons of ore at the mill, producing 390.85 tons of concentrates. The silver recovered from the mill concentrates was 509,073.62 ounces. The actual production for the year was 1,456,894 ounces of silver shipped. The cost of production was 16 cents per ounce. The high-grade averaged 6413 ounces of silver to the ton and the mill concentrates averaged 1302 ounces to the ton.

The first annual report of the **Schumacher Gold Mines, Ltd.**, to June 30, 1916, shows ore reserves of 64,900 tons, valued at \$396,700, averaging \$6.11 per ton. The plant consists of the following: Compressor building, containing two electrically driven air compressors, delivering 1500 cu. ft. free air per minute; two 135-hp. boilers and one double-drum Jenckes hoist, a fully equipped blacksmith shop, shaft houses with two cages, new office buildings, a complete assay office, refinery, mine manager's bungalow, thaw house, pumping station with a 3-in. water line, mill of the continuous decantation-type, with a capacity of 150 tons per day, and other smaller buildings.

The mill has been in operation since the middle of September, 1915. The results obtained from Oct. 1, 1915, to June 30, 1916, are as follows:

Month	Tons Milled	Operating Cost	Cost per Ton	Bullion Production	Production per Ton	Net Profit for Month	Profit per Ton
October, 1915	2,355	\$11,365.11	\$4.82	\$16,703.24	\$7.09	\$5,338.13	\$2.26
November	2,570	13,416.47	5.22	14,261.10	5.54	844.63	0.32
December	2,970	13,515.31	4.55	14,527.20	4.89	1,011.89	0.34
January, 1916	2,800	14,663.93	5.24	13,663.78	4.88	*1,000.15	*0.36
February	2,950	14,833.42	5.02	14,963.99	5.07	130.57	0.05
March	4,020	16,780.29	4.17	19,919.09	4.95	3,138.80	0.78
April	4,130	15,971.83	3.86	22,341.95	5.41	6,370.12	1.55
May	4,225	15,322.86	3.62	21,188.84	5.01	5,865.98	1.39
June	4,100	15,850.20	3.86	24,379.82	5.94	8,529.62	2.08
Interest	30,120	\$131,719.42	.....	\$161,949.01	.....	\$30,229.59	.....
Rentals		340.03	.....		.....		.....
Cash discounts			.....	212.50	.....		.....
Solutions (not included above)			.....	1,828.50	.....	1,703.16	.....
	30,120	\$132,059.45	.....	\$163,992.20	.....	\$31,932.75	.....

*Loss.

It will be observed that in spite of the rapid and continued rise in the cost of the supplies, a marked reduction in the operating costs was made in the latter part of the year ending with June 30, 1916. While the cost per ton for the first five months ending with Feb. 29, 1916, was \$4.96, the average cost for the four months ending with June 30, 1916, was \$3.88. The net profit for the former period was \$6,325.07, while for the latter it was \$23,904.52.

Development of Our Potash Industry*

By F. M. deBeers

President Swenson Evaporator Co.

American chemists have been looking for potash in this country for a great many years, and several deposits and sources were discovered years ago and then neglected by capital because of the moderate price of the German article. Most, if not all, of the present sources were known before the war, but the industry did not seem then to promise returns large enough to warrant the hazard of the new undertaking. Consequently nothing was done until our supply was suddenly cut off, and a brief review here of what we bought on the average per year from Germany may not be out of place.

In round figures the following list shows approximately what we imported each year:

	Tons
Potassium muriate (80%)	250,000
Potassium sulphate (90%)	50,000
Manure salts (20-38%)	200,000
Kainit (12-15%)	500,000
Total	1,000,000

Figuring all the potash as K₂O or potassium oxide would show about 360,000 tons of the oxide in the above importation. Our yearly supply of German potash cost us about \$20,000,000 before the war. During the balance of this paper when I refer to percentage of potash I will mean per cent of potassium oxide or K₂O.

The question of whether we can produce this large amount of potash here and take care of our increasing demand is entirely too large for me to even consider, particularly as no one seems to know when the war will end and what Germany plans to do then. We know she can produce potash very cheaply, and we also know we have large but scattered supplies of potash-bearing materials here, but the whole thing is in too primitive a state now to warrant any guesses. Some of our present developments will survive any competition, but others are simply intended to fill a present demand.

In this paper I am only attempting to explain where we can secure our raw potash salts and what has been done up to the present that has come to my notice. The refining and purification of these raw salts has been done here before the war, and our large chemical companies can without doubt take care of this phase of the situation. Some of these raw salts can, of course, be used in their raw state in certain industries. Most of my information is first hand, and my estimates as to quantities are, of course, approximations. I wish here to say that some of my information was obtained from reports by experts in other industries, and to all these men I acknowledge my indebtedness.

Our sources of supply can be divided into two classes, one containing those which are by-products, and the other class consisting of industries where potash is the principal product. We will consider the by-product potash first.

By-Product Potash

POTASH FROM WOOD ASHES

Wood ashes have been a source of potash ever since our ancestors knew how to use same. After the German industry had developed, the making of potash from ashes was practically abandoned, but lately, I believe, our supply is being augmented from this source.

I have not been able, however, to locate any data that is sufficiently complete and reliable as to what we can expect in total tonnage, etc. I am of the opinion that

*An address made before the American Meat Packers' Association in Cincinnati October 10, 1916.

this source is not of very great importance from a commercial standpoint.

POTASH FROM BITTERN

Bittern produced in the manufacture of salt from sea water, contains potash, but the quantity is very small and it is very difficult to separate from other salts.

Bittern from the water of our Great Salt Lake is now being treated by three companies, and this runs about 2 per cent potash. Each company has its own method of separation and purification, and if they all operate up to their expected capacity they could turn out approximately 30,000 tons of raw salts per year, running about 20 per cent potash. This figure is only approximate, as before stated, but it will serve to show that this source is not very important and high freight rates to Eastern points make it appear as if this process might have a hard time surviving after the war. The bittern also contains about 5 per cent magnesium oxide, and because of same my conclusion may be unfair.

POTASH FROM WOOL

Wool is scoured or washed before it can be made into yarn, and this wash water contains about 3 per cent total solids after the wool, grease and dirt have been separated out. These solids will average over 25 per cent in potash and are easily recovered.

This material is available at the Atlantic seaboard, and because of the value of the wool grease, it is very probable that the manufacture of potash in this way can be commercially successful. Another reason for saving this waste lies in the fact that by doing so this objectionable wash water is not run into streams or sewer systems. While the potash made should be easily marketable, the quantity obtainable from this source cannot be very great, and I regret I have no figures as to tonnage. The potash is in the form of carbonate and potash soaps.

POTASH FROM FISH WATER

Fish water produced in menhaden factories contains about 8 per cent solids, and these solids will average 5 per cent K_2O and over 16 per cent ammonia. This cooking water should be saved and can be converted into a most profitable by-product. The industry is not a large one, however, and not more than 15,000 tons of dry fertilizer averaging as above could be produced per year based on the average kill of our Atlantic factories for the past five years.

POTASH FROM SUGAR FACTORIES

In the making of alcohol from cane molasses, there is a liquid residue left in the still which contains 5 per cent solids. These solids will average 9 to 10 per cent potash and also contain some ammonia. The potash is probably in the form of carbonate and sulphate. A few distilleries are now saving this slop and recovering the potash. If all the slop made in this way were saved and the solids recovered, we could count upon a production of about 200,000 tons of 10 per cent potash per year as a maximum, and I am inclined to believe that this estimate of mine is a little too high.

Many of our beet sugar factories employ the Steffens process for recovering the sugar from their molasses, and after the sugar is made in this way there remains a waste solution averaging about 4 per cent solids. Approximately half our factories have this waste material. These solids can be recovered, and many European factories are doing so, but up to the present time our sugar makers, with a few exceptions, have done nothing.

A dry product made from Steffens water will average over 6 per cent in ammonia and over 12 per cent

in potash in the form of carbonate. Our American farmers will probably produce 7,000,000 tons of beets this year, and if the Steffens process were used in every factory and all the water were saved, we could count on about 200,000 tons of product every year of the above analysis. We are expecting a decided and permanent increase in our production from this source within the next year.

POTASH FROM CEMENT PLANTS

In the manufacture of cement, the dust leaving the furnace carries a considerable quantity of potash salts, and these are being recovered by several methods. The most successful seems to be the Cottrell system, and very large returns are obtained according to several authorities. I have estimated roughly that we could produce about 80,000 tons of potash annually in this way if the figures given me are correct.

It is sufficient to say that several plants are now using this process successfully, and one plant is now being built near Buffalo that will turn out potash as the main product and cement as a by-product. This, of course, is a development of the feldspar situation to be discussed later.

POTASH FROM BLAST-FURNACE GASES

Furnace gases from blast furnaces contain potash due to the volatilizing of the potash salts by the high temperature. This probably produces potassium cyanide, and the amount of potash that passes away is enormous. My own figures seem so large that I am afraid of them, mainly because I have not had any direct experience or contact with this problem.

If the statements of authorities who have written in high-class journals are correct, this is one of our largest sources of potash, and is no doubt being investigated thoroughly (and quietly) by the large producers of pig iron. The dust which settles in the stoves and boilers is now collected and sold to refiners of potash salts, although I could not find any data as to quantity.

Potash the Main Product

This about takes care of the development of our by-products as a source of potash. The remaining sources can be grouped under four headings, kelp, alunite, western lake waters and feldspar. There are some other minerals which contain potash, but personally I have not learned of any which are in sufficient quantity to be considered.

POTASH FROM KELP

The making of potash from kelp is being carried out with partial success on the Pacific Coast. The present high value of this material and the absolute necessity of securing a supply has made it logical for some large users to put up plants for this purpose, and they are good investments no doubt for these reasons.

I cannot see how this can be a permanent industry with potash at the price it was before the war unless some one perfects a process that will permit of a lower cost of production. This, of course, is only my private opinion, and I hope I am wrong, which is easily possible, as I have not had the opportunity to study the matter as closely as I would like to. If the kelp is thoroughly dried or burned, I am told it is possible to secure a product running over 15 per cent potash. So far as I know, no figures are obtainable as to production.

POTASH FROM ALUNITE

Potash from alunite is being successfully made in Utah and I believe this industry is a permanent one. One of our large packers is responsible for the first commercial plant and I am told that outside of the set-

backs which must be expected in such a new development, the process is a success.

According to my own figures which are simply estimates, I would say that the production next year should be at least 20,000 tons of potassium sulphate 90 per cent pure—a very high-grade product.

Other plants are now being contemplated and we may soon have a much larger output. The ore itself runs from 8 to 12 per cent in potash and the process of manufacture is relatively simple.

POTASH FROM WESTERN LAKE WATERS

The largest source available for quick use is out in Western Nebraska and Wyoming. This field to my way of thinking is also a permanent one and after the business has been standardized and the necessary experience secured, I believe our Nebraska friends can compete, if necessary, with Germany within a reasonable shipping radius.

There are a large number of these small lakes running from a few acres up to several hundred acres apiece. Those containing potash salts have vegetation around their banks, while the alkali or soda lakes are barren. You will very often find two lakes side by side with potash in one and not in the other.

Experts are now at work trying to locate the source of the potash that drains into these ponds and if they are successful, we will probably be relieved of any worry as regards our supply. These lakes or ponds will average 10 to 15 per cent total solids and these solids when dried will contain from 15 to 30 per cent potash depending upon which lake is being worked. A fair average would be $12\frac{1}{2}$ per cent solids containing 20 per cent potash.

One small lake alone which is being worked now is said to contain over 300,000 tons of these salts. A large number of lakes have been bought and will be developed as soon as the new plants can be finished. It should not cost over \$5 per ton to make the final dry product and this allows liberally for every item of cost so it will be understood why I say that this field should be permanent at least for a good many years before the lakes are drained. I should say that by the first of next January, we will be getting 20 per cent potash salts from this district at the rate of 100,000 tons per year as a minimum.

Oregon has several lakes that contain very large quantities of potash as sulphates and carbonates. Some work is being done, but so far as I know, there have not been any developments on a commercial scale up to the present time. I learned of one lake recently that I am told contains 18 per cent total solids of which 8 per cent is potassium carbonate which certainly sounds very interesting.

Searles Lake in California contains a large quantity of potash and a great deal of money has been and is being spent to produce a marketable product. The problem is not an easy one as the brine contains a mixture of potassium and sodium sulphate, carbonates, chlorides and borates. They are very hard to separate, although I know that several hundred thousand dollars has been spent on a plant within the last year by the American Trona Corporation which anticipates a large tonnage of potash salts soon. The brine used contains over 30 per cent total solids with about 5 per cent of potassium chloride. The company is figuring on an output of 40,000 tons per year of 80 per cent muriate and so far as supply is concerned, they could operate at many times that rate for years to come as the lake is very large.

POTASH FROM FELDSPAR

Feldspar occurs in so many localities that we are all hoping that some American chemist will soon solve the

problem of how to make potash from same on a commercial scale. The supply is practically unlimited. It averages from 8 to 15 per cent potash in the form of silicate and aluminate.

One syndicate of miners in Colorado is producing 2000 tons of finely ground and washed feldspar each day which is all ready for a satisfactory process.

Hundreds are experimenting and if I had time I would be glad to explain some of the methods being tried. As soon as an economical method is discovered, we need have no fear about our supply, but such a method must be able to produce at a cost comparable with Germany's cost, which up to the present time has not been done to the best of my knowledge.

CONCLUSION

I have not attempted to explain any particular process used in making potash from any of these raw materials as such information to be complete would result in a book, rather than a paper. After studying this question as carefully as possible, I am of the opinion that we will produce raw potash salts next year in sufficient quantity to supply about one-third of our average demand before the war or equivalent to 120,000 tons figured as potassium oxide (K_2O).

There is a chance that we may exceed this by 50 per cent if certain properties are worked or if new processes are developed, but even then we would have but half our requirements during normal times and right now we could really use more than that. Our future as a large producer depends entirely, to my way of thinking, on our success with feldspar, alunite, blast furnace gases, Searles Lake, and other lakes in Nebraska, Wyoming and Oregon. We cannot secure much more than about 15 per cent of our requirements from the by-products first discussed, although many of these should be permanently profitable.

Chicago, Ill.

American Electrochemical Society's Next Year's Meetings

The 1917 spring meeting of the American Electrochemical Society will be held in Detroit and the autumn meeting in Pittsburgh. No definite dates have yet been fixed.

Chemistry of Gas Lighting

The New York sections of the American Electrochemical Society and the Illuminating Engineering Society have arranged for a joint session to be held at the Engineering Societies' Building, 29 West Thirty-ninth Street, New York, on Thursday evening, at 8 o'clock, Nov. 9.

A very attractive program has been prepared, including papers by E. L. Knoedler of the Welsbach Company on "The Most Recent Developments in Incandescent Gas Mantles," and W. R. Addicks, vice-president of the Consolidated Gas Company of New York, on "Some Notes on Gas Standards."

The October issue of the *General Chemical Bulletin*, the house organ of the General Chemical Co., contains much that is interesting concerning the activities at the various plants of the company. Considerable space is devoted to safety and general welfare work and to athletic activities, and there are also some technical news of more than passing interest. This well edited Bulletin is a credit to the company.

The *Electron Chemical Company* of Portland, Me., manufacturers of the Allen-Moore electrolytic cell have opened a New York office in the Woolworth Building.

Glimpses of New Pacific Coast Industries in the Making

Impressions from a Flying Editorial Trip to California

(Concluded from page 288)

CHEMISTRY IN SOUTHERN CALIFORNIA

It has been said that Los Angeles, Southern California's metropolis and the home of the cafeteria and the jitney, has only one highly developed industry: real estate. Truly if California is famous for her boosters, the real estate boomers of Southern California must be mentioned in the front rank. Talk with any one you meet in Los Angeles, be he a bank president or an oil engineer or a sugar man or a hotel clerk or whatever else, and inquire about real estate, you will find at once cordial attention. Whatever else they may do in life, they are all, each in his or her big or little way, interested in real estate and willing to sell you lots. And if you are daring enough to drop a word about the quoted prices of the lots, you will be quickly and convincingly told that God's country is limited in area and that the demand is increasing and that according to the law of supply and demand everything is as it should be.

In a country that depends so directly and almost exclusively on the products of its virgin soil, it is clear that industrial chemistry can play an important part only in a limited way in a limited number of industries. In Southern California it is chiefly in connection with the immense oil and gas industry and the beet sugar industry that chemists have become indispensable. This has been so for years and their importance is increasing. At Oxnard, not far from Santa Barbara, is the largest beet sugar factory in the world. And everyone knows what the oil wells mean to Southern California—and to the automobilists of the whole country.

Yet in this comparatively simple wave form of chemical activity, with its two fundamentals of oil and gas and of sugar, overtones are becoming distinctly audible. Last year we commented on the admirably progressive work of the Kieselguhr Company of America at their mine and mill at Lompoc in Santa Barbara County; here again Californian soil offers directly something extraordinary, an infusorial earth of very unusual purity; but its utilization in the industries in the form of silocel for heat insulation and in the form of filtercel for filtration in many fields has required and is requiring very extended chemical research work. It is a pleasure to state that ever increasing success crowns the persistent efforts of this American pioneer industry.

During this year's trip a new theme was predominant in many variations—potash. But before we take up this subject we must mention some electrochemical developments. In some way their existence was rather unexpected.

ELECTROCHEMISTRY AT LOS ANGELES

For large-scale electrochemical developments in which large amounts of electric power are required, Southern California, which derives 50 per cent of its present electric central-station generating capacity from water-power and the other 50 per cent from steam, is not so lavishly favored by nature as Northern California with its large amount of hydro-electric power developed and awaiting development under rather favorable conditions. But whether it is on account of the labor situation—the difference between union-ridden San Francisco and open-shop Los Angeles—or just accidental, in one line of electrochemical endeavor at least, that is the use of the electric furnace in the steel industry, Los Angeles is ahead of San Francisco.

At Redondo there are several electric steel furnaces, consuming in the whole 800 hp. The original American Stassano furnace installation at this place was described in our Vol. XI, p. 709.

Then the Ford Motor Car concern uses electric baking and enameling furnaces consuming 600 hp.

An installation of 150 hp., producing oxygen and hydrogen by electrolysis of water, may be mentioned in the same connection, as it is used for welding and cutting purposes in the steel industry.

It was rather gratifying and certainly interesting to learn from Mr. S. M. Kennedy, general agent of the Southern California Edison Company, that his company had received in the recent past numerous inquiries from Eastern concerns on rates for power.

To conclude the notes on electrochemical developments as well as introduce the subject of potash, it is our pleasure to say something of a very enjoyable visit to the Western Precipitation Company's laboratories at Los Angeles.

WESTERN PRECIPITATION COMPANY

This company for chemical and metallurgical engineering research is itself one of the most interesting developments of chemistry in California. It is unique no less in origin and scope than in the arrangement of the building. This is built according to the ideas of its genial general manager, Mr. Walter A. Schmidt, as a square with a square court or garden in the center. The four surrounding buildings, all interconnected, serve as office building and laboratories. From all of them a free view is had of the central court; it is really very pretty and below the ever-blue sky of Southern California this ever-green garden is a continuous source of inspiration to the workers in the laboratories. The accompanying photograph shows just one corner of the central court.

The Western Precipitation Company is electrochemical in origin, being an outgrowth of the electrostatic fume and dust precipitation process of Dr. Cottrell, California's greatest contribution to electrochemistry and electrometallurgy. In promoting the Cottrell process and introducing it into practice, the Western Precipitation Company has paid special attention to dust recovery in cement mills.



JUST A CORNER IN THE CENTRAL COURT OF WESTERN PRECIPITATION COMPANY'S LABORATORIES



FIG. 1—ONE OF THE HARVESTER BARGES, LORNED MANUFACTURING COMPANY, LONG BEACH, CAL.

Its pioneer plant in this field is at the Riverside Portland Cement Company at Riverside, Cal. The process was installed there originally as a protective measure—to prevent the orange groves in the neighborhood from being damaged by cement dust. But it was found then that the dust recovered could be made a source of potash; although the percentage of potash in the raw mix was only 0.2, the dust recovered contained potash in quantities which made it worth while recovering, and such recovery is now made.

While it is in a certain measure a war baby, yet this development is bound to stay after the war is over. Figures shown to us by Mr. Schmidt of the amounts of potash which may be recovered in this way from cement mills, are very encouraging. It is certainly significant that the Security Cement & Lime Company at Hagerstown, Maryland, has installed the same system under license of the Western Precipitation Company and is now recovering potash on a commercial scale.

But we would not do justice to the Western Precipitation Company's work, if we only spoke of their connection with the Cottrell process and potash recovery. The scope of their work is very much wider and comprises practically the whole of chemical and metallurgical engineering. To mention only two very extended researches carried out at the laboratories, one has to do with an important phase of sulphuric acid manufacture, a second one with the problem of leaching copper and other ores. While the main offices of the company are at Los Angeles, it has branch offices at Philadelphia, Vancouver, B. C., Frankfort on Main, Germany, Lon-



FIG. 2—KELP DROPPING OFF THE CONVEYOR ON TO THE BARGE—THE BLACK SPOTS IN THE WATER ARE KELP GROVES

don, England; Melbourne, Australia; Santiago, Chile, and Yokohama, Japan.

POTASH

But the Western Precipitation Company is by no means alone in Southern California in endeavoring to find a solution of the potash problem.

The Searles Lake scheme on which a great deal of money has been spent, is progressing further and it is hoped that finally a solution of the rather difficult problem of separating the various potassium and sodium salts in a commercial and economic process will be found. When that is the case, Searles Lake will be an important source of supply of potash.

But other sources of potash are by no means neglected as we learned from Mr. Edgar Baruch, chemical engineer of Los Angeles. One of the latest developments, still in the state of evolution at the time of our visit, is the recovery of potash in sugar plants.

But most attention is probably paid to the recovery of potash from kelp or seaweed. As a general review of the various endeavors in this line with a brief sketch of the different companies was given in our issue of April 1, 1916, (Vol. XIV, p. 355), reference may be had to that article. We will give here only a sketch of the American Products Company or Lorned Manufacturing Company at Long Beach, where we spent a very enjoyable forenoon. By the way, it has been said—we will not argue with how much truth—that Los Angeles itself is in many respects but an outgrown town, but then it must be added—and there is no doubt of the truth—



FIG. 3—PRECOOKER FOR SEPARATING SALT-BEARING LIQUOR FROM PULPOUS MATTER (NOT IN USE IN NEW PROCESS)

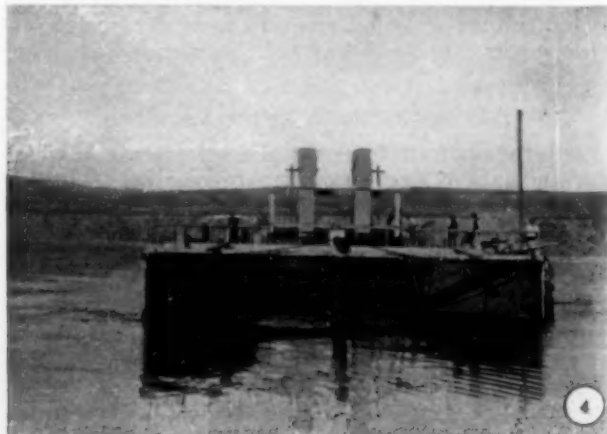


FIG. 4—HARVESTER IN KELP FIELD, LORNED MANUFACTURING COMPANY, LONG BEACH, CAL.

that the redeeming feature is the lively spirit of her many beaches.

PLANT OF AMERICAN PRODUCTS COMPANY

The American Products Company, with rather extended works at Long Beach, has been largely financed by Mr. G. W. Simmons, vice-president of the Simmons Hardware Company of St. Louis, Mo. The development of the process in operation is interesting and in a sense typical.

The process originally used by the American Products Company was that of Mr. Isaac Naylor. The characteristic feature was that the potash salts were extracted from the seaweeds, without burning them up, so that in addition to the potash salts, a by-product of cellulose or pulpous matter is obtained which is of itself of sufficient value, thus assuring the profitable operation of a potash plant under normal conditions.

Mr. Naylor had for years been devoting his energies to the creation—from waste materials—of useful articles of commerce. He first manufactured a small barrel from corn-stalks and also from the pulp of sugar cane (known as bagasse). A quantity of these kegs were filled with nails and shipped many thousand miles by rail and water. Not one of them broke or failed to arrive at destination with contents intact.

During his experiments in this fiber process, Mr. Naylor conceived the idea of treating kelp by similar chemical and mechanical methods, as he had used in producing the nail kegs. He succeeded in procuring a pulpous material from which a satisfactory barrel was made and in addition he released the liquid matter of the seaweed containing the potash salts, so that the two products were simultaneously produced. Further experiments developed the fact, however, that this pulpous material still contained from 10 to 12 per cent of potash salts and contained as well more than 2½ per cent of nitrogen and a similar quantity of phosphoric acid. It was, therefore, found that the material commanded a higher market price as the base of a fertilizer than for the construction of barrels or railroad ties or other materials made by the fiber process.

Starting in October, 1915, a complete potash and fertilizer factory was erected at Long Beach and is being operated by the Lorned Manufacturing Company. The plant was first operated by the Naylor process and was producing for a time about five tons daily of high-grade muriate of potash (97 per cent) and as a by-product about 30 tons daily of a potash fertilizer averaging from 12 to 25 per cent of potash with over 2 per cent each of nitrogen and phosphoric acid.

However, in large-scale operation the Naylor process which had worked ideally in the laboratory, proved prohibitive in cost. Being essentially a wet process, the cost of evaporation was too great and the Naylor process in its essential details had to be abandoned.

It is to the great credit of the present general manager of the plant, Mr. Leslie H. Thompson, to have put the plant on a paying basis by a simple radical change. He cut out the whole first steps of the Naylor process and changed the wet process into a dry process. No by-products are now recovered but all efforts are centered on the direct and most inexpensive production of potash. Three tons of muriate of potash of 97 per cent is the present daily output. Iodine was not yet recovered at the time of our visit, but it was stated that the recovery of iodine would be a simple matter.

This evolution from the complex to the simple is in a way typical. We can repeat here what we said in our first article (Sept. 15, p. 286) concerning the Noble Electric Steel Company: that it is a mistake to try to do too much at once, that the first aim of an operating man

must be to make the operation successful in the main object and as foolproof as possible. The experience of the Lorned Manufacturing Company is new evidence for the correctness of this fundamental operating principle.

Mr. E. J. Porteous is the chemist of the Lorned Manufacturing Company.

Our thanks for courtesies received are due to the general manager, Mr. Leslie H. Thompson and our congratulations on the final success of this pioneer undertaking to him as well as to Mr. G. W. Simmons.

The threatening railway strike prevented our intended visit to the Hercules Powder Company's immense new plant at San Diego.

It is certainly pleasing to watch the enormous activity in the commercial recovery of potash from kelp. Yet while it is right and good to make the most of the kelp that Nature is abundantly providing, we might pay a little attention to a more fundamental problem: In which way are potash and iodine concentrated by Nature in kelp from sea water? What is the character of the semipermeable diaphragm or generally what is the mechanism of the concentration process? If only a partial solution of these questions was found it would be a great step forward.

Current News and Notes

Mining and Metallurgical Society.—At a regular meeting of the New York Section, held on Oct. 19, at the Engineers' Club, Morrill B. Spaulding was elected chairman to fill the office declined by W. R. Ingalls, who was elected at the annual meeting.

General Discussion on Refractories.—The Faraday Society will hold a general discussion on "Refractories" at their first autumn meeting, the date of which is provisionally fixed for Wednesday, Nov. 8, 1916. The discussion will be presided over by Sir Robert Hadfield, president of the Society, and the opening paper will be read by Dr. J. W. Mellor.

Gasoline from Natural Gas.—The output of casing head gasoline in 1915 was 53 per cent greater than the 1914 output according to the U. S. Geological Survey. The quantity of raw gasoline extracted in 1915 was 65,364,665 gal. The volume of gas used in the manufacture of this gasoline is estimated at 24 billion cubic feet. The number of plants engaged in the industry increased from 386 at the beginning of the year to 414 at the end.

Paper-Making Industry in Russia.—The improvements in the Russian paper-making industry are continuing. A considerable increase in the export of pitprops, wood pulp, etc., from Archangel during 1915 is reported, the quantity being 11,648,755 cu. ft. for 1915, while that for 1914 was 7,285,696 cu. ft. Developments are also taking place in the Siberian paper industry, new plants being under construction at Gorochoff and at Krasnoyarsk or Irkutsk. The I. E. Yatess paper works are being formed into a company; the Volojod and Tver district council are contemplating the erection of a paper factory in the northern timber areas of Siberia and Russia near the town of Taiga. According to reports, the annual paper consumption of Siberia is 36,000 to 54,000 short tons per year. (Commerce Reports, Oct. 10, 1916.)

Census of American Blast Furnaces.—The United States Bureau of Census has made a preliminary statement of the 1914 census of manufactures of blast furnaces in the iron and steel industry. There are 162 establishments reported, employing 33,194 people. The primary horsepower is 1,222,273; the capital involved is \$462,282,000. The cost of the materials

treated is \$264,580,000, and the value of the products obtained is \$317,654,000. The value added to the above by manufacture is \$53,074,000. (Commerce Reports, Oct. 6, 1916.)

Wood Pulp Industry in New Zealand.—The New Zealand Wood Pulp & Paper Manufacturing Co., Ltd., has been incorporated with headquarters at Christchurch. Much developing work is being done and it is expected that the company will turn out 20 to 25 long tons of paper daily. Most of the paper will be turned out in rolls for newspapers. The daily consumption of paper of this type is estimated at 40 tons, and it is believed that all the paper turned out by the above company will find a ready market in the newspaper line. (Commerce Reports, Oct. 5, 1916.)

Graphite and Carbon Electrodes in England.—Up to within very recent times, Great Britain has imported practically all electrodes used in the smelting and refining of iron and its ores from the United States. New installations of a number of electric furnaces at Sheffield have created a greater demand for electrodes. To part way satisfy this growing demand, the Electrode Co., Ltd., of Sheffield, has been organized with a capital of \$243,325, for the manufacture of carbon electrodes, and a plant is under construction which it is expected will be in operation within the next three months.

The promoters of this company are four large manufacturing concerns which have installed or have in process of erection 23 electric furnaces, with a total capacity of 90½ tons. The new company will have an estimated output of from 3000 to 5000 tons of carbon electrodes per year. (Commerce Reports, Oct. 5, 1916.)

D. R. Sperry & Co., Batavia, Ill., have designed and constructed for the new plant of the Armour Fertilizer Works, Chicago, a 54-in. evaporator, barometric condenser, autoclave and wood filter press. An order has been received from Wilson & Company, packers, for eight recessed-plate filter presses for its new plants at Chattanooga, Tenn., and Oklahoma City, Okla.

The **Claud S. Gordon Company**, formerly of 7415 Vernon Avenue, Chicago, will soon open a new shop at 646 East Seventy-fifth Street, Chicago, which will be used to handle the increased demand for pyrometer service, determination of fusion points and general research work in high temperatures.

Pocket CO. Indicator.—The Bacharach Industrial Instrument Company has issued a pamphlet describing a new flue gas analyzer which has been developed by this company. It is stated to be handy, compact and accurate.

The **Cutler-Hammer Manufacturing Co. of Milwaukee**, has removed its Cleveland office from its location in the Schofield building to modern and more commodious offices on the twelfth floor of the Guardian building, Euclid Avenue. This is the fourth time since its establishment, seven years ago, that the office in this city has been compelled to double its quarters. G. S. Crane, assistant manager of the central district, continues in charge of the Cleveland division. The central district covers the western half of Pennsylvania, West Virginia and three-quarters of Ohio, with completely equipped sales offices in Cleveland and Pittsburgh. The district is in charge of A. G. Pierce, manager central district, with headquarters in Cleveland and Pittsburgh.

The **Doehler Die-Casting Co.** announces the removal of its brass-back bearing department from the Brooklyn to the Toledo plant. An entire new factory building, housing foundry and machine shop, fully

equipped with all modern labor-saving devices, is devoted to the manufacture of "Doehler" babbitt-lined brass-back bearings.

Galalith.—Galalith is a bonelike substance, in many respects resembling celluloid. This product is essentially of German origin and has been on the market for several years. It is manufactured from casein by means of formaldehyde. A solution of casein is obtained by treating skimmed milk with caustic alkali or carbonate. This solution is clarified and the casein precipitated by means of acids and then filtered. The water is then partly extracted by pressure and the product dried very slowly. The drying process extends over a period of several weeks. The plates of casein thus obtained are thoroughly saturated with formaldehyde and again submitted to drying. The product is somewhat transparent, of a yellowish-white color and very similar to horn. If a colored or mottled product is desired, coloring matter is added to the casein solution, or powdered cork, soot, wood pulp, earth, etc., are kneaded into the precipitated casein. Acetate of lead is also used for precipitating casein. The specific gravity of galalith is 1.317 to 1.35, and its hardness is 2.5, according to Mohs' scale.

Galalith is an excellent insulating material and may be utilized either in a cold state or after it has been softened in hot water. It is free from odor and is less inflammable than celluloid. It is never absolutely transparent and cannot be manufactured in thin sheets.

The material is becoming of more and more importance, at least in Germany, which is indicated by the fact that Germany is making inquiries in regard to the import of skimmed milk from the United States for the purpose of manufacturing galalith. Small amounts of this product have been shipped to the United States. The figures in terms of dollars were: 1912, \$10,769; 1913, \$12,007; 1914, \$16,395, and for the first six months of 1915, \$6,274. (Commerce Reports, Oct. 10, 1916.)

Sulphur in Wyoming.—The Midwest Sulphur Co. with their property located at Cody, Wyo., has been notified that a cave has been discovered on the Laramie River, two miles from the quarries whose walls are lined with high-grade sulphur, 3½ to 4 ft. in thickness. The cave is approximately 30 ft. in length and 40 ft. in width. The product is an especially pure one, analysis running as high as 99.00 per cent in sulphur. The material may be shipped without further purification.

The Metal Production of New Mexico in 1915.—According to the U. S. Geological Survey the metal production for New Mexico for the year 1915 was \$19,279,368 against \$11,049,932 for 1914. The distribution of the values was as follows: Gold, \$1,461,005; 2,005,531 oz. of silver; 76,788,366 lb. of copper; 4,542,361 lb. of lead and 25,404,064 lb. of zinc. These figures show an increase of \$289,309 in gold, 228,086 oz. of silver, 17,480,441 lb. of copper, 2,778,720 lb. of lead and 7,000,672 lb. of zinc. The value of the metals, except silver, was higher than in 1914.

Production of the Dome Mines, Ontario, for September.—The Dome Mines for the month of September treated 38,300 tons of ore, producing \$179,500 in gold. The average value per ton of ore was \$4.886 and the estimated cost \$2.59 per ton, giving an average profit of \$2.09 per ton. These figures show a falling off in production as compared with August. For the latter month the Dome treated 40,100 tons of ore worth \$180,000 at an average value of \$4.49 per ton. The operating costs for August was \$2.56 per ton, \$2.61 for July and \$2.62 for June.

Why Our Chemical Import Statistics Should Be Overhauled*

By Bernhard C. Hesse

On three previous occasions¹ I have pointed out in more or less detail the need of a revision of our chemical import statistics, more particularly to the need of a finer subdivision of the itemization of the entries, and have indicated how this might be accomplished.

Assurances of enthusiastic and sympathetic co-operation have been received from a number of technical and commercial associations and organizations, as well as from the Department of Commerce and from the United States Geological Survey. Many high executive officers of domestic chemical manufacturing and merchandising enterprises have assured me of their belief and faith in the great potential good residing in such an effort, and editors of our leading trade publications, such as the *Oil, Paint and Drug Reporter* of New York, and the *Paint, Oil and Drug Review* of Chicago, have in sincere and emphatic editorials seriously commended this endeavor to the thoughtful consideration of their readers, and have urged intelligent and prompt co-operation.

It is, therefore, only reasonable to assume that these proposals bear, on their surface at least, evidence of potential constructive good for the country at large. It now remains for us to realize this supposed potential good. To this end the co-operation of all the sections of the American Electrochemical Society and of the American Chemical Society has been solicited, and there is plenty of evidence of a whole-hearted desire on the part of all to contribute all they can and to co-operate to the extent of their opportunities and ability.

As a result of considerable correspondence with sectional secretaries and of conversations with a number of local councillors during the holding of the Second National Exposition of Chemical Industries last month, it has seemed to me that after all I had not succeeded in clearly bringing out the crux of the situation, so that all were clear as to just what was wanted and as to how it might be done, although quite a number of sectional secretaries did fully get the ideas and suggestions conveyed by my publications and have proceeded accordingly.

In view of the situation as a whole, it may be well to say what are not the objects of this project, since many seem to have obtained enlarged notions of its scope and which would be unworkable.

1. We are not now concerned with exports in any sense.
2. We are not now concerned with prices or quantities in any sense.
3. We are not now concerned with locus of import or consumption.
4. We are not concerned at any time with the names of users or importers.

What we are after is the names, and the names only, of those things that in normal times come to us from abroad and are used by or can be made by a branch of our chemical industry.

For example, what material of construction or what chemical raw materials come to us from abroad which our domestic chemical industry in any branch thereof needs?

What materials that can be made by a branch of our domestic chemical industry are imported?

It must be noted that quantities, prices—unit or

otherwise—and locus of consumption are wholly irrelevant and immaterial, and any attempt to superimpose those data upon the simple request for names only of materials, etc., will very likely lead to confusion and embarrassment and probably refusal. It is merely a qualitative list we are now after.

Now, why should we want such a list and why bother you with the labor of finding that list out? That is a question that I have been frequently asked. The answer to that is that the person does not live who can formulate a sure-enough definition of a product of or for chemical industry that will be intelligible to any one, and that would answer our purposes. Obviously our government cannot feasibly list separately each of the thousands upon thousands of different articles that enter our ports, and if it did so list them many of them would not be used. Just think of the sized volume that such a list would require! Since a verbal definition is out of question, the only refuge is in illustration. Now, your answer, like others, may very well be: "Tell the government we want all products of and for chemical industry listed item by item. Given them a copy of all chemical catalogues and tell them we want to know all about each item in those catalogues." Now the answer to that kind of an answer is that it is no answer at all. Self-evidently we as American commercial, industrial or manufacturing chemists cannot possibly be interested in every chemical listed in every chemical catalog, and moreover, we are interested and deeply so in many things that never are mentioned in any chemical catalog of any kind. For the same reasons we cannot refer the government to any one of the numerous Buyers' Guides. We cannot give the government a blanket list for the simple reason that there is no such list. England, France, Germany, Sweden, Canada, Switzerland, Italy and the United States, each and all have a different official notion of where products of and for chemical industry begin and end. Our own government's list is not adapted to our best service and I am sure that none of the other government's lists would be satisfactory, I have compiled such a composite list which has been published in at least four places.²

Your next question will probably be: "What will you do with that list after you get it?" To that the answer is that the Central Committee, of which I am a chairman, will, if the response is satisfactory, compile all of the submitted material into a composite list and ask the government to give us the quantities and values imported monthly, quarterly or annually as may appear best suited to our needs.

Then you will say: "Be sure and get a good classification; have it logical and scientific; the present classifications are so illogical and so unscientific." The answer to that is that we cannot, in reason, ask the government to alter its mode of collecting and classifying its information; all we have a right to do is to ask for a finer subdivision of the items reported. The reasons, among others, for this are:

The original sources of information are the consular invoices which are filed with the Treasury Department; for the purpose of determining the duty to be levied, the items of each invoice are classified or marked according to the relevant tariff law paragraphs and the duty rate stated.

In making up its returns the Treasury Department is primarily interested in the amount and value of dutiable goods entered under each of the paragraphs and the duty collected, and to a secondary or subordinate

*A paper read at a joint meeting of the New York Sections of the American Chemical Society, the American Electrochemical Society and the Society of Chemical Engineers.

¹*Journal of Indus. and Eng. Chem.*, 1915, p. 58; 1916, pp. 672 and 749. *Proc. Am. Inst. Chem. Eng.*, 1914, p. 42. *Metallurgical and Chemical Engineering*, 1916, p. 143. *Oil, Paint and Drug Reporter*, July 31, 1916, p. 16. *Paint, Oil and Drug Review*, August 16, 1916, p. 11.

²*Metallurgical and Chemical Engineering*, Aug. 1, 1916, p. 143; *Journal of Indus. and Eng. Chem.*, 1916, p. 749. *Oil, Paint and Drug Reporter*, July 31, 1916, p. 16. *Paint, Oil and Drug Review*, Aug. 16, 1916.

extent as to the nature, quantity or values of the various items under each of those paragraphs. Then the Department of Commerce takes these invoices or the collated records of the Treasury Department and selects from them those items that it has reason to believe are specifically of interest to the public. Now, that is where we come in. We must tell the Department of Commerce with as great practical and practicable detail as we now can what specific items we as industrial chemists are really interested in. We cannot seriously be interested in every single item imported by any one or all of our chemical supply houses, and for that reason to have the government go to all that trouble would be in large part useless labor. The best we can do is to give the government the best sort of a line that we can on what we are really interested in.

At this point you will no doubt say: "Now, won't your committee get a lot of duplications in names and how am I to know what some other section reports?" The answer is: "Never mind about duplicates; you send in your stuff; duplicates are our troubles and we will handle that."

Still you may say: "Must I get a complete list of all we are interested in?" The answer is: "Not at all; just tell us what things are lacking in the various lists published in the *Journal of Industrial and Engineering Chemists* for August, 1916, or in METALLURGICAL AND CHEMICAL ENGINEERING for Aug. 1, 1916, or *Oil, Paint and Drug Reporter* for July 31, 1916, or *Paint, Oil and Drug Review* for Aug. 16, 1916, in which you are interested and we will do the rest. That is one way of doing it and as near as I can figure it, it is the shortest and easiest way, and further, it is the way I suggested in the article containing those lists. If you prefer to do it some other way—go to it, but get there!

"In other words, if our commerce reports were to list separately all the items given in all those various lists would your section of the country and its interests be taken care of? If not, what do you want added to those lists? All we want is the name of every addition you want."

Then you will probably ask: "What good do you expect from all this trouble you are asking us to go to?" The answer is: "Suppose antimony oxalate (which is not now reported in our reports) were shown to be imported in increasing quantity quarter by quarter, some domestic maker might make up his mind to go after that market and bag it for himself; tally one for the list! For we would be just that much nearer independence, and so on *ad lib.* Some day you might be the lucky man to make a ten-strike."

By this time, if you are like most of those to whom I talked during "Chemists' Week" in New York, you will begin to show signs of great personal interest and you may ask: "Will I have to dig through those big volumes every month to find out about these thousand-and-one-things." The answer is: "Not at all, if the A. C. S. is alive and on the job. The government cannot reasonably be expected to get out a separate publication for us chemists; if it did it would have to do so for every other branch and there would be many overlapping. For example, suppose the leather industry to want such a separate list; many of its items are on our list, and so on down the line. The A. C. S. will have to separate out that information every time such a government report comes out and publish it in the *Journal of Industrial and Engineering Chemistry* and so that not everybody goes to sleep and gets the idea that that information is published merely to take up space, I should like to see a standing head something like the following:

"The information herein given was collected by our

government in the expectation that with its help our chemists will most intelligently and effectually work toward the self-containedness of the nation."

"This standing head would be a constant reminder to our members that they are expected to make intelligent and constructive use of that information, and also a reminder to our government that it too must keep awake and tell us of any newcomers so soon as they show up."

As I see it, the real lesson of the war to us as a people should be that our national well-being requires a diversified industry as well as an industry turning out large quantities. Up to twenty years ago or thereabouts Germany was largely engaged in diversifying her industry, and for the past twenty years or somewhat longer she has been engaged in "mass-production," so that for many years past Germany has had not only a highly diversified industry, but also one dealing in and producing large tonnages.

We have the large tonnage capacity and point of view, but we do not have the diversified industry point of view, and it is in order that we may acquire this latter in the shortest possible time that this present work has been undertaken.

With this fragmentary and sketchy introduction I will proceed to the more fundamental aspect of the case.

For upwards of thirty years the attitude of the country as expressed in three Republican and two Democratic tariffs and one Democratic partial tariff-revision, has been that our chemical industry in general and coal-tar dyes, in particular, shall not be protected and that any tariff laid on chemicals and dyes shall be non-protective and for revenue-yielding purposes only. The tariff efforts at protection were and are directed toward other industries.

Immediately upon the outbreak of the present war our press and the public severely scolded us chemists for not making coal-tar dyes; dyes seemed to be the limit of their information as to what chemists do. Many other and more important things which were in the same condition as dyes were overlooked, deliberately or otherwise, in this tirade and this fusillade of criticism. The reason was and is clear. The raw cotton market has been shot to pieces and fabricated cottons then on the market were made from high-priced cotton and buyers demanded sales at the then prevailing very low raw cotton prices; thereupon the manufacturers set up the dye-stuff bogey to bolster up their demands for higher prices for fabricated cottons. Going behind the scenes, it is clear that this demand for dyestuff independence is, far more likely than not, artificial, and in the light of the experience of thirty years past, insincere and thoroughly non-dependable. Economic beliefs of the two political parties and the business policies of the nation more than thirty years old cannot be expected to be overturned so suddenly and such sudden alleged change cannot be sincere nor lasting, panic-time conversions and statements to the contrary notwithstanding. The chemists of the country will simply be living in a fool's paradise if they bank on it that the above view of our industry by the public has undergone or will soon undergo any lasting change.

In his speech of acceptance on Sept. 2, 1916, President Wilson said: "We have driven the tariff lobby from cover and obliged it to substitute solid argument for private influence." While this may be true as a general statement it does not at all apply to the inside history of the making of the dyestuff section of the Kitchin General Revenue bill. Leader Kitchin himself says that it was a compromise between the Hill bill rates or no added rates at all. The Kitchin rates are and were dictated solely by private influences privately exercised and

rest upon no "solid argument" nor public proceedings whatever; they are merely the result of "take what the dye-users offer you or you get nothing at all." A few only of the dye-users forced this situation; let no one be deceived, the big influences in the dye and chemical using field are not behind this movement at all. When the right time comes, and signs to that effect are already evident, those influences will have any rates above the Underwood tariff taken off, and taken off quickly at that, for they probably will not be permitted to raise the duties on their own finished products; then our domestic dye and chemical makers will be as badly off as ever, and our chemical industry instead of having been helped forward will have been given a "black eye" by the very politicians who professed to be its friends. The underlying reason for this on-the-surface solicitude for the welfare of our domestic chemical industry by both political parties is votes and is not dictated by any primary or real desire for a domestic chemical industry; our politicians are not yet educated up to that point. It has been variously estimated that 400,000 or 800,000 votes are to be found among the operatives of the dye-using industries; by some political legerdemain both political parties hope to convert this alleged dye-stuff solicitude into a solicitude for the welfare of those voters. The chemists of the country are worth hardly 10,000 votes to the politicians.

Further, it must be remembered that among domestic dye and chemical users the feeling is growing, "Well, we were more scared than hurt; we 'got by' this time; it's a long time to the next war; we should worry! Let others take care of themselves; we want cheap dye-stuffs and cheap chemicals and we do not care who makes them; dyes and chemicals are our raw materials and raw materials must be free."

On the theory of the "greatest immediate good to the greatest number," and this is perhaps for the present and the immediate future properly expressed by the number of influenceable or affected votes, it is reasonably certain that our country will not lastingly reverse itself in its fiscal and economic policy of the past generation. Products of chemical industry are not themselves and as such very largely sold to the "ultimate consumer," that is, the voter. They are largely used in making things that are made by and do reach the voters, and to those who make these things that thus reach the voter the products of chemical industry are raw materials, and the country long has been and still is fairly well united on the proposition that "raw materials must be free," and particularly where the making of those so-called "raw materials" in this country will not directly affect many—particularly voters.

Contrary to all the expectations raised by the recent discussions of the press, the country seems to have set adrift its new-born desire to insure to those industries that it has a domestic supply of such of their raw materials as are in reality highly manufactured products of other industries and has definitely decided to continue in this respect to be dependent upon foreign nations.

Based upon the classification and the figures of the census of 1909, and if we compare the average chemical plant with the average plant in all domestic industries, it appears that the average chemical plant, when so contrasted, costs 330 per cent of that general average, employs 144 per cent as many persons, of which the salaried employees are 264 per cent of the general average and the wage earners 134 per cent; the output value is 261 per cent of the general average, and its enhancement in value is 248 per cent. Therefore, as a unit, the average domestic chemical plant costs more, produces more, enhances more, employs more salaried

persons and more wage earners than the average industrial plant.

A dollar invested in our chemical industries is not so productive as in our industries as a whole; it spends less for wages, salaries and materials and produces less product-value and less enhancement-value.

Per \$100 of product, the general average and the average domestic chemical plant, respectively, expend \$16.58 and \$9.09 for wages, \$4.54 and \$5.65 for salaries, or \$21.12 and \$14.74 for services.

Per individual wage earner the annual output of product is \$3,125 for the general average and \$6,035 for the average domestic chemical plant.

Per individual salaried employee the annual output of product is \$26,157 for the general average and \$25,733 for the average domestic chemical plant.

Relatively, our chemical establishments are 0.79 per cent of all our industrial establishments, and the number of persons employed is 1.15 per cent of all persons employed in manufacture.

So that while an average chemical plant, as such, is of greater importance to the community than the average industrial plant, yet the capital so invested is not so productive as in the average industries. It is possible that sooner or later the American public will decide that our national well-being requires greater development along chemical lines since chemical products are raw materials for so many domestic industries, and will be prepared to take what steps may be necessary to accomplish that result, but until that time arrives we chemists must be prepared to make our own way, and on our own merits and independently of any economic help from politicians, for we must remember that whatever one set of politicians may give us another set of politicians can take away; such artificial help may merely be producing more of these undesirable ventures known as "war babies."

Obviously, therefore, we chemists cannot stop to quarrel with the facts, but we must simply make friends with the situation as it is. These are simply "the rules of the game." The country does not want to help us broadly, as is for the sixth time and conclusively proved by the happenings of the past two years, and yet the country, in a half-hearted way, wants and really should have a chemical industry—complete to be sure—but it will have to be content with what it can get in that direction. It is our duty to give the country the utmost that we can give it. We have done the best possible under the conditions of the past and present. In order to help our country more we must know with considerable particularity what our country buys from abroad. If our country wants us to help more than we have heretofore the country must tell us more than it has in the past. Chemists are not mind-readers nor clairvoyants. When the country says: "We import \$800,000 worth a year of fifty different chemicals," what good does that do it or do us? Could anything be more tantalizing to chemists? Why not tell us what those fifty things are and how much of each and at what price it reaches this country? Then we might be able to do something additional. Why should we be called upon to guess what these fifty items are and what their respective values and poundages are? The country has that information and why hide it?

If the chemists of the country were fully informed as to the values and amounts of imports into this country of products of and for chemical industry, we could then more intelligently and more surely work towards the self-containedness of the nation, and more completely utilize to the utmost all opportunities around us; if, then, added economic help in certain directions were clearly needed, and if by then President Wilson's

above statement has actually been realized with respect to our products and the country really wants our industry, it seems only reasonable to expect that such added help would then be forthcoming, promptly, permanently, willingly and intelligently.

Our first duty, then, is to tell the country how we suggest to have this added information imparted; then, if the country does really give us that, it will be our second duty to take hold of the opportunities thus disclosed and make them give up all they can be made to give up; we can then cross the next bridge when we come to it. In the meantime we have our hands full trying to get this request for more information into presentable and convincing form.

In making up this list of import items we must bear in mind that it should contain everything that a well rounded-out and self-contained chemical industry needs either in materials or apparatus or makes in the way of products, finished or intermediate, for its own use or for use in other and wholly non-related industries, and this is much more varied than any available list of such products; this is our real task—to make the list complete in every respect.

The function of such a complete list is three-fold: Firstly, it will inform government officials and the public of, and will visualize to both, the variegated and ramified activities and interests of chemical industry; secondly, by its illustrative character it will enable our government officials to "spot" a relevant newcomer in our field much more readily than otherwise; thirdly, it will tell us chemists ourselves a great deal more about our own business, our own opportunities and our obligations to other industries than any collection of text or handbooks ever could. It is rather a "tall order," but if we will not make up such a list why should we expect others to do our work for us? And who else should do it? It is our job and no one's else.

When considering the taking up of making things in this country that are up to then largely or wholly imported from abroad, we must bear in mind that, in general, increased domestic consumption follows domestic manufacture so that an imported item of \$10,000 per year may in a few years of domestic manufacture reach a consumption of three or four times that figure.

Finally, it must not be lost sight of that when we ask for greater subdivision of the items of imports in our commerce and similar reports we are not at all asking for a revision of the general classification. These reports can convey the same financial and other information as to the sources and amounts of revenue as heretofore; we do not ask to have this function of those reports curtailed nor hampered in the least; all we ask is that they be made to contain and to give more detailed information as to our items of purchases of products of and for the chemical industry from abroad.

25 Broad Street,
New York City.

Salt Evaporation.—According to the United States Geological Survey, the United States produced 38,231,496 bbl. of salt in 1915. The larger part of our salt is produced by converting rock salt lying deep below the earth's surface into brine, artificially, then pumping said brine to the surface and evaporating it. Some idea of the values thus obtained may be best given by citing the statistics for the salt obtained in this manner in the states of Michigan, New York and Kansas. In Michigan, 6,708,261 bbl. of salt were obtained by means of evaporation, having a value of \$3,635,692, New York produced 3,443,464 bbl. valued at \$1,720,434, and Kansas 1,901,756 bbl. were marketed at \$696,060.

An Explanation of the Flotation Process*

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The flotation process for the concentration of ores is a method by means of which one or more of the minerals in the ore (usually the valuable ones) are picked up by means of a liquid film and floated at the surface of a mass of fluid pulp. Here they are separated from the other minerals, which remain immersed in the body of the pulp. In general, the minerals which are floated are sulphides of metallic luster, but some other minerals of metallic luster such as graphite and some sulphides with adamantine luster, such as sphalerite and cinnabar, are amenable to treatment by the process.

The importance of flotation lies in the fact that it is primarily a "slimes process," by means of which the particles of valuable mineral, too fine for efficient gravity concentration, are saved with a high percentage of recovery. Recoveries in the mills treating low-grade copper sulphide ores have been advanced 10 to 20 per cent by the installation of the process, and similar increased savings have been accomplished by the same means in mills treating sulphide ores of zinc and lead.

When finely ground ore containing sulphides mixed with a siliceous or earthy gangue is brought gently onto the surface of a body of water, in a direction forming an acute angle with the surface of the water, a considerable portion of the sulphide constituent of the ore floats on the surface of the liquid, while the gangue sinks. This is the so-called film flotation, exemplified by the Wood and Macquisten processes.

When gas bubbles are introduced into a fluid pulp composed of finely ground ore and water, to which has been added (1) a small amount of certain oils, or (2) a small amount of certain acids or acid salts, or (3) a small amount of certain alkalies or alkaline salts, or (4) a small amount of a mixture of oil with acid or alkali, the sulphide particles in the ore are brought to the surface on the gas bubbles. These collect in a froth heavily laden with sulphide particles. The gangue particles are not brought up by the bubbles, but remain in the mass of the pulp. This is the so-called froth flotation. Its variations, acid-froth, agitation-froth, and pneumatic-froth processes are discussed in detail later.

The points to be explained in the operation of these processes are: (1) The flotation of solid particles in a liquid the specific gravity of which is less than that of the solid; (2) the preferential flotation of the sulphide portion of the mass; (3) the functions of the reagents used.

Theory

The theory here presented in explanation of the points listed in the preceding paragraph appeals to the following physical phenomena: Surface tension, adsorption, adhesion, and viscosity. The first three of these are closely related.

SURFACE TENSION

Every liquid surface in contact with a gas or its vapor behaves as if it were under tension. The value of this contractile force per unit width can be measured. Its value for water, 74 dynes per centimeter, is higher than for any other well-known liquid. (Liquid metals and fused salts are, of course, excepted.) This fictive tension is a convenient conception for many discussions and may be explained in terms of the intermolecular attractions of the substances forming the

*A paper read at the Arizona meeting of the American Institute of Mining Engineers, September, 1916.

boundary. Another and very useful way of considering the phenomenon is to regard each unit of surface as having associated with it an amount of potential energy which is numerically equal to the surface tension. This relation is established as follows:

If two wires, *A* and *B* (Fig. 1), are so placed as to slide on two fixed wires *C* and *D*, and if the wires *A*

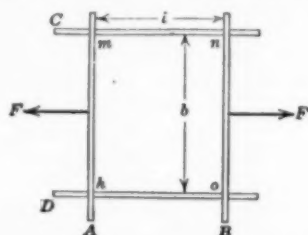


FIG. 1—POTENTIAL ENERGY OF SURFACE TENSION

and *B*, having been in contact, are separated a distance *l* against the pull of one of the surfaces only of a film, *mnoh*, by applying the force *F* the work per unit area will be

$$\frac{W}{A} = \frac{Fl}{lb} = \frac{F}{b} = T$$

which is obviously equal, numerically, to the force per unit width or the surface tension *T* of the one surface considered. Applying this conception of surface energy to different cases of contact, we can develop some statements of the relations of forces which are important in explaining many of the phenomena observed in flotation.

Consider first that two blocks of liquid, which have become rigid without any change in their other properties, are drawn together by the mutual action of their forces of molecular attraction until they perfectly unite over an area *A*. They would do an amount of work that we will represent by the letter *W*. Now consider that the same two bodies when brought near together, but not into contact, become liquid and unite over the area *A*. The work done is again *W*, but in this case it can be considered as due to the shrinkage of the surface by an amount *2A*, whence $2AT = W = A(T_1 + T_2)$, where *T* is the surface tension of the liquid. If two different liquids whose surface tensions are *T*₁ and *T*₂, respectively were brought together, the work due to the molecular attractions would be $(T_1 + T_2)A = W$, provided there was complete union, but if there is not complete union, there will be an interfacial tension *T*₁₂, and the energy equation becomes

$$(T_1 + T_2)A - T_{12}A = W$$

or

$$T_{12} = T_1 + T_2 - \frac{W}{A}$$

i.e., the interfacial tension *T*₁₂ is the excess of the sum of the two tensions over the work which is done by them in allowing a unit area of the two liquids to come into contact. If a liquid is brought into contact with a solid, the energy equation is $T_{1s} = T_1 - W_1$ (gas or vapor effects being excluded),

where *T*₁ = the surface tension of the liquid,

*W*₁ = the work done in bringing a unit area of the liquid and solid into contact,

and *T*_{1s} = the interfacial tension.

If, therefore, *W*₁ = *T*₁, the solid has the same attraction for the molecules of the liquid as the molecules of the liquid have for each other and there will be no interfacial tension. If *T*₁ > *W*₁, the interfacial tension *T*_{1s} will be positive; if *T*₁ < *W*₁, there will be negative inter-

facial tension or a surface pressure. In the latter case the liquid will tend to spread over the solid.

ANGLE OF CONTACT

When, as is the common case in the flotation process, there are three substances in contact, a system of forces as shown in Fig. 2 is brought into play. If *O* does not move indefinitely to the right or to the left, equilibrium will be attained when

$$T_{sl} = T_{gs} + T_{gl} \cos \theta$$

or

$$\cos \theta = \frac{T_{sl} - T_{gs}}{T_{gl}}$$

where *T*_{gs}, *T*_{gl}, and *T*_{sl} are the interfacial tensions or pressures at the gas-solid, gas-liquid, and solid-liquid contacts respectively. From this equation is deduced the important conclusion that as *T*_{sl} increases with respect to *T*_{gs}, the angle of contact θ becomes smaller (the gas and liquid being the same), or, in other words, the angle of contact is a measure of the tendency of one fluid to replace another on the surface of a solid. We have examined the angles of contact of the water-air, oil-air, and oil-water surfaces against a number of the common minerals. We have found, in general, that the air-water contact angle is less for gangue minerals than for sulphide minerals; that the air-oil contact angle is less for sulphides than for gangues and less for any given sulphide than the air-water contact angle, and that the water-oil contact with solids takes the form shown in Fig. 3.

We found further that the invariable effect of oiling

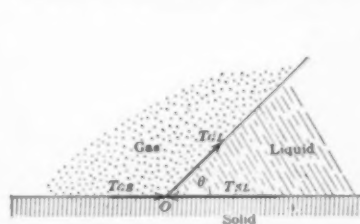


FIG. 2—CONTACT ANGLE

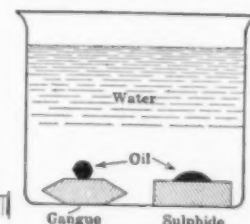


FIG. 3—WATER-OIL CONTACT WITH SOLIDS

a solid surface is to reduce the air-water contact angle. This latter phenomenon is undoubtedly aided by the reduction of the surface tension of the water due to contamination by the oil. This is further discussed later.

The conclusions forced by observation of the above phenomena are:

1. That water has a smaller tendency to displace air on the surface of sulphide minerals than on the surface of gangue minerals.
2. That the tendency of oil to displace air is greater at the surface of sulphide minerals than at the surface of gangue minerals.
3. That oil tends to displace water on the surface of sulphides and that water tends to displace oil at the surface of gangue minerals.
4. That water displaces air more readily on an oiled solid surface than on a clean surface of the same solid.
5. That these tendencies toward displacement are due to the interfacial tensions or pressures existing between the various substances, and that the resulting action of these interfacial forces is a manifestation of the tendency toward reduction of the total potential energy of the system. Wherever an increase in the solid-fluid interface will decrease the potential energy, such a change will occur.

These conclusions suggested the following confirmatory experiment.

A ring, 6.17 cm. outside diameter and specific gravity of 1.38, made of aluminium tubing, 0.63 cm. diameter, was cleaned and floated without trouble on the surface of pure water. The shape of the water surface at the air-water contact is shown in Fig. 4. The ring was then oiled slightly. The air-water contact angle was reduced, as shown in Fig. 5, to such an extent that it was impossible to float the ring. The same was true,

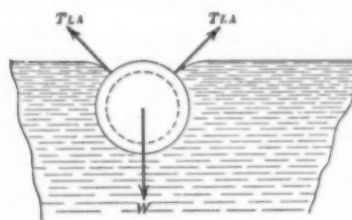


FIG. 4—SHAPE OF WATER SURFACE AT AIR-WATER CONTACT. THE ALUMINIUM TUBING UNOLED

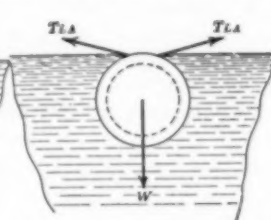


FIG. 5—CHANGE OF CONDITIONS DUE TO OILING THE ALUMINIUM TUBING

as might be expected, when a cylinder of aluminium replaced the ring. A similar cylinder of glass tubing exhibited such a small air-water contact angle that it could not be floated.

ADSORPTION

The surface layer between two physical phases is the seat of conditions of density and viscosity, also of apparent forces or energy manifestations, which are notably different from those in the bulk of either phase. On philosophical grounds it is impossible to consider that a real physical discontinuity occurs at the boundary between two media. In other words, there must be a very thin layer of transition in which there is a rapid but continuous change in the concentration of the components. This change in the concentration of a component at the interface is called adsorption, and may occur even between two phases which are ordinarily regarded as immiscible.

Adsorption at a gas-liquid interface may be demonstrated as follows: If a solid, which has been heated in a vacuum, is introduced into a measured volume of a gas over mercury in a calibrated tube, an amount of the gas will be adsorbed, as is shown by the change in pressure and volume compared to the space originally occupied.¹ These additional facts are established.

- The amount of the gas adsorbed at constant temperature increases with the pressure.
- It is different for different gases.
- It is different for different solids.
- It increases as the temperature decreases.
- There is an energy transformation which is indicated by the heat developed through adsorption, analogous to the Pouillet phenomena mentioned later.
- Chemical reactions are assisted by the adsorbed layer.

It follows that the gas layers must vary in density, falling off rapidly with increasing distance from the solid. Quincke assumes that the density of the gas next to the solid is equal to that of the solid, and concludes that the amount adsorbed will increase with the density of the solid. From these facts we conclude:

- That gases and solids exhibit selective adhesion, and that, therefore, gas bubbles will attach themselves more persistently to some substances than to others.
- That this selective adhesion is a manifestation of a definite amount of energy possessed by each unit area of a gas-solid contact, and that this potential energy is capable of variation.

3. That chemical reactions which diminish this potential energy are aided by adsorption.

Adsorption at a liquid-solid surface manifests itself in a vacuum, or where the vapor phase is negligible, by the way in which the liquid spreads or gathers itself together on the solid; in other words, in the way in which the liquid wets or adheres to the solid. It is further manifested by an evolution of heat, known as the Pouillet phenomenon. A calculation of the condensation necessary to evolve this amount of heat, in the case of water against glass, indicates that the specific gravity of water in the adsorbed layer is increased to about 2.1.²

Adsorption of the gas at a gas-liquid surface is indicated:

1. By the effect on the surface tension. The surface tension of a freshly formed mercury surface does not change in a vacuum, but falls off in the presence of different gases for about an hour. Certainly the density of a liquid cannot be constant at the boundary, but must go over continuously into that of the gas.

2. By the increase in the solvent power of the surface.³

3. In the case of contaminated liquids, by the concentration of one or more of the components of the liquid at the gas-liquid surface. Every unit area of such a boundary possesses a definite potential energy which always tends to a minimum. If, therefore, the surface tension of a solution depends upon the presence of any component, such a change of concentration of that component will occur as will reduce the potential energy, i.e., the interfacial tension. In other words, any component which reduces surface tension will be found in excess at the surface of a solution. For example, the surface tension of water is greater than that of alcohol. Experimentally, a drop of alcohol on a thin film of water rapidly reduces the surface tension of the water and the latter draws away from the alcohol. On the contrary, a drop of water on a thin film of alcohol spread over glass does not at once diffuse into the film but remains gathered in a heap. Such diffusion would increase the surface energy of the system, hence the water concentrates away from the gas-liquid surface. The greater viscosity of the surface of a solution above that of the bulk, or of that of a pure liquid, has long been recognized⁴ by its damping effect upon a swinging magnetic needle and may properly be ascribed to gas-liquid adsorption. Closely connected with this is the formation of elastic solid skins or very viscous layers at a free surface, as, for example, in the case of solutions of peptone and dyestuffs. A peculiarity of saponine solution is the rigidity of its surface while the interior remains more mobile.⁵ The surface of a freshly formed fairly concentrated solution of fuchsin is quite mobile, but in the course of a few hours it changes to a reflecting skin with solid properties. Similar results are obtained with methyl-violet and peptone. In the case of the latter substance the skin is highly elastic. There seems to be no doubt that true adsorption is present here. In the case of crystal-violet, which closely resembles methyl-violet in its properties, a solution of 1 g. to liter lowers the surface tension from 75 to 69.9 dynes per centimeter. Other causes for the production of a solid layer may, however, be present, for many of these substances in concentrated solutions stiffen into gelatines and since the concentration of the contaminant is great at the surface and the solubility has also a different value, the solid remains persistently. Either a chemically irreversible change or a transformation into a more difficultly soluble

¹ Freundlich: *Kapillar Chemie*, p. 92.

² Lewis: *Phil. Mag.*, 20, p. 502, 1910.

³ Pockels: *Nature*, Mar. 12, 1891, p. 439.

⁴ Daniels: *Physics*, p. 253, Fr., p. 76.

⁵ Boys: *Soap Bubbles*, p. 115.

phase at the surface is clearly the explanation of the persistence of the froth in albumen solution and the like. The properties of such surfaces apparently pass over imperceptibly into those of colloids.

Adsorption at the boundary between two liquids is evidenced by the effect on the interfacial tension just as in the gas-liquid solution surface, although the process is not one usually described as ordinary solution and one may also have to reckon with chemical reactions in the transition layer. With liquid-liquid surfaces, as in gas-liquid surface, the adsorption frequently gives rise to very viscous layers. The presence of such a viscous layer at an oil-water interface is easily shown by pouring any clear oil, kerosene,

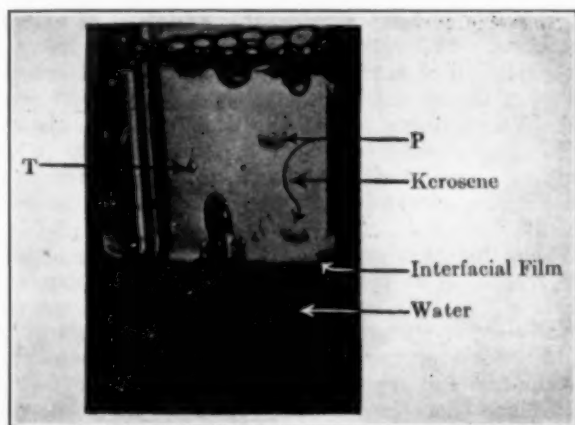


FIG. 6—EXPERIMENT VISCIOUS FILM AT OIL-WATER INTERFACE

liquid vaseline, etc., onto water and then bubbling a gas through the water. Such an experiment is shown in Fig. 6. The interface has all the appearance of an elastic skin. Bubbles rising through the water and striking the under side of the interface stretch the film (see *H*, Fig. 7), and rising farther drag away a mass of water surrounded by this viscous layer. The system now appears as shown at *M* and rises to the oil-air surface on account of its lower specific gravity. Here the film, together with the excess water carried

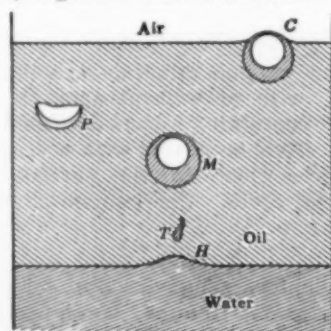


FIG. 7—DIAGRAMMATIC REPRESENTATION OF EXPERIMENT OF FIG. 6

up as shown at *C*, breaks away and falls back through the oil, not in spherical form, as would be the case were the water drop not surrounded by a viscous film, but in hemispherical form (see *P*, Figs. 6 and 7) often trailing behind it a film with ragged edges, as it broke from the bubble. The tadpole-shaped water drops, *T*, (Figs. 6 and 7) are further evidence of the high viscosity of the oil-water interfacial film.

VISCOSITY

A marked increase in the viscosity of interfacial films is produced by the presence of finely divided solid

matter. This increase is apparent in the experiment just described when finely powdered sulphide is thrown into the oil and allowed to settle to the interface, where it becomes entangled in the film. When gas bubbles are introduced, as before, the return water drops, coated with a film containing the solid particles, are much more irregular in shape than previously, and their coalescence after reaching the interface requires days or weeks.

An even more convincing proof of the increase in viscosity of an interfacial film is given by the following experiment. If a needle is floated at the center of a surface of pure water in a beaker 4 in. in diameter and a chip of wood is floated near the wall of the beaker, the needle, may be caused to revolve by means of a magnet without disturbing the chip. If the surface of the water is dusted over with fine ore, the whole surface together with the chip moves as though it were a rigid solid.

SUMMARY

The potential at a gas-sulphide contact is less than at a gas-gangue contact; hence gas bubbles will cling with greater persistence to sulphides than to gangues.

Oil replaces water at the surface of sulphide minerals.

Water replaces oil at the surface of gangue minerals.

Water replaces gas more readily at an oiled surface of a solid than at a clean surface.

The addition of any contaminant to water lowers the surface tension.

In any body of contaminated water there will be a concentration of the contaminant at the air-liquid surface.

Adsorption at a gas-liquid surface lowers the surface tension and increases the viscosity.

Adsorption at a liquid-liquid surface produces a film whose viscosity is higher than that of the bulk of either liquid.

The presence of finely divided solid matter in a film markedly increases the viscosity of the film.

Application to Commercial Flotation Processes

FILM FLOTATION

Pulp with or without oil or acid is fed gently, at an acute angle, onto the surface of a body of still water. The sulphide floats and the gangue sinks.

Possible cases:

Case 1.—Sulphide, gangue, water.

Case 2.—Sulphide, gangue, water, oil.

Case 3.—Sulphide, gangue, water, acid.

Case 4.—Sulphide, gangue, water, acid and oil.

Case 1. Sulphide, Gangue, Water.—The governing factor in the initial flotation of the sulphide and immersion of the gangue is the difference in the air-water contact angle with the sulphide and gangue surfaces respectively. If the difference is great, as in the case with galena and quartz, good separation is obtained. After a considerable amount of sulphide has been floated, if the surface flow is sufficiently impeded, the particles congregate into clumps by the well-known phenomenon of apparent attraction of floating particles,* a scum is formed (whose viscosity and resistance to rupture are many times greater than that of the original water surface) and the floated particles are rendered more immune to immersion.

Case 2. Sulphide, Gangue, Water and Oil.—When oil is added in this process the phenomena are entirely different from the simple film flotation of Case 1. The

*Hastings and Beach: *General Physics*, p. 156.

oil concentrates at the surface since such concentration reduces the surface energy of the system. This adsorption of the oil at the gas-water surfaces causes the formation of a viscous film. When the mixture of sulphide and gangue is introduced at the surface, the sulphide particles tend to migrate into this layer and the gangue particles migrate into the water, for a sulphide particle in contact with oil represents the condition of least potential energy which is possible for the sulphide particle to assume in the system of oil, sulphide, and water. Likewise the gangue particle surrounded wholly by water represents the condition of least potential energy for the gangue particle to assume in this system. In this case also, the formation of a scum of floated sulphide increases the stability of the float.

Case 3. Sulphide, Gangue, Water and Acid.—The effects of acid are: (a) to diminish the surface tension of the liquid, (b) to diminish the gas-liquid contact angle, and (c) to increase the viscosity of the gas-liquid surface. The diminutions of (a) and (b) are more marked with gangue minerals than with sulphides. The result is that cleaner concentrate may be expected than in either of the previous cases, but at the expense of richer tailing.

Case 4. Sulphide, Gangue, Water, Oil and Acid.—In this case a combination of results such as can be predicted from the preceding cases is obtained.

FROTH FLOTATION

In order to explain froth flotation it is necessary and sufficient that the gas of each bubble shall be inclosed by a film of contaminated water which shall possess the following characteristics:

1. Low surface tension.
2. High viscosity.
3. A variable concentration of the contaminant (reagent).
4. A preferential adhesion of the bubble film to the sulphide mineral compared to that for the gangue minerals.

We will examine first the conditions required for the formation of a froth, or the continued existence of a thin film. Solutions which form froth are preëminently aqueous solutions and the properties of the liquid film are only secondarily determined by those of the gas.

The durability of a liquid film depends upon one or more of the following conditions:

1. A low surface tension which is locally variable so as to produce stable equilibrium.
2. High viscosity, which may pass over into
3. Chemical irreversibility and the production of solid skins.

Pure liquids do not foam; for example, water or alcohol. The reason is obvious. As the film is thinned out by stretching or by draining away of the liquid, the surface tension is reduced at some part below the general constant value. As soon as this begins the thicker and more powerful parts of the film drag away from the weakened parts which at once completes the rupture. These inequalities evidently would not be so marked or rapid in their operation if the surface tension were low. Increase of viscosity would also slow up the process. High viscosity and low surface tension do not occur in pure liquids. But the most important condition for durability is some means by which the equilibrium of the forces at any point in a film may be restored, when a variation of some of the forces occurs. In the case of a compound liquid or solution this is effected by the adsorption or change of concentration of one or more of the components in the film.

The surface tension of a solution is in general notably different from that of the pure solvent, and in case of water, whose surface tension is the greatest of any

liquid with which we are concerned, even a minute trace of impurity is sufficient to lessen its surface tension considerably.

Consider a film of water stretched on a vertical ring of wire. If the surface tension remained constant, as it does in the pure liquid when the thickness exceeds 0.000001 cm., the weight of the lower part would stretch down the upper part until it broke. If the water contains some component whose depletion at the weaker points increases the surface tension, equilibrium will be preserved. In the stretching of a film, and in the general running away of the liquid between the surfaces of the film, which reduces the total available amount of the contaminant, such decrease of the concentration and increase of surface tension does occur, and the film remains stable under a considerable variation of external conditions. The formation of bubbles as a result of this variation of surface tension alone is well exemplified by a simple aqueous solution of soap or of acetic acid. The running out of the liquid between the two surfaces is greatly retarded by the viscosity of the liquid, a property which may be largely influenced by the surface adsorption of one or more of the components.

When, then, gas bubbles are introduced into a liquid pulp where oil is present there is formed about each bubble a liquid film whose surface tension is less and whose viscosity is greater than that of the bulk of the liquid. Some of the solid particles of the pulp move into the film and are raised to the surface with the bubble. Since there is a concentration of oil in the film, and since the diminution in potential energy at an oil-sulphide contact is greater than at a water-sulphide contact, the contaminated layer replaces the water on the sulphide surface and the sulphide moves into the bubble film, while the gangue, on which water displaces oil, remains in greater measure in the body of the pulp. The bubbles, therefore, as they arrive at the surface, carry an excess of the sulphide minerals. Upon their arrival at the surface, the bubbles of the contaminated liquid persist, owing: (1) to their lower surface tension; (2) to their ability to adjust this tension to a state of stable equilibrium; and (3) to their greater viscosity which is markedly increased by the presence of the solid particles.

MECHANICAL-AGITATION FROTH PROCESS

Sulphide and gangue minerals are beaten up with water and oil, with or without acid, then allowed to flow into a box containing a considerable body of liquid nearly at rest. Bubbles coated with a preponderance of sulphide particles float to the surface and form a heavy, persistent froth. The gangue particles sink.

Two cases arise:

Case 1.—Sulphide, gangue, water and oil.

Case 2.—Sulphide, gangue, water, oil and acid.

Case 1. Sulphide, Gangue, Water and Oil.—When this pulp is beaten, air is mechanically entrapped in the form of bubbles. At the surface of every bubble in the mass there is a gas-contaminated-liquid contact which results in the adsorption at this surface of the contaminant, oil, and the production of a viscous film into which the sulphide particles, circulating in the mass, pass with a diminution in the potential energy of the system. The result is that in a very short time after the air bubble is entangled in the pulp, it is surrounded by a viscous sheath composed of an oil-water interfacial film in which are entangled a large number of sulphide particles. The presence of the solid particles greatly increases the viscosity of the bubble sheath. When the solid-coated bubble arrives in the settling box or spitzkasten it rises to the surface. Here

the bubble persists, or, bursting, transfers its load to other bubbles. This bubble persistence is due to a combination of several factors. The oils used have, in general, a slower evaporation rate than water. The tension of the bubble film is lower than the tension of a pure water bubble. The bubble has the power of adjusting itself to its tension, within limits, without bursting. The presence of the large amount of solid matter enormously increases the viscosity of the film.

Case 2. Sulphide, Gangue, Water, Oil and Acid.—The addition of acid has the twofold effect of further lowering the surface tension and increasing the adhesion ratio $\frac{\text{oil-solid}}{\text{water-solid}}$.

The result is, in general, cleaner concentrate with or without an increase in the sulphide content of the tailing.

Heating the pulp has, in some cases, a beneficial effect. Where this is true it is probably due to (a) decreased surface tension and consequent increased stability of the froth; (b) increased number of air bubbles formed by the air released from solution; (c) in the case of viscous oils, the greater area over which oil is spread and consequently the greater number of bubbles with a viscous oil-water interfacial film; (d) probable increase in solubility of the oil and consequent greater diffusion, resulting in more widespread adsorption in bubble films.

PNEUMATIC FROTH PROCESS

Sulphide and gangue minerals mixed with water and oil, with or without acid, are run into a tank with a porous bottom through which air is forced. The air bubbles rise to the surface with a coating of solid particles, preponderantly sulphide, while the gangue particles sink.

The principles involved in this method are the same as explained in the agitation-froth process. The only difference is in the method of introducing air. The result of this difference is that the bubbles in the pulp are much larger than in the agitation froth method; they arrive at the surface less heavily loaded in proportion to their area; the bubble films are, therefore, less viscous, and the froth less persistent.

POTTER-DELPAT PROCESS

Sulphides and carbonates, with or without other gangue minerals, are treated with hot, dilute sulphuric acid. Bubbles of carbon dioxide and hydrogen sulphide are formed which rise to the surface with a sulphide coating and there form a froth. That part of the gangue not dissolved remains immersed. In this method as in the other froth methods, gas bubbles are formed which are surrounded by films of contaminated water, the contaminants in this case being sulphuric acid, lead sulphate, calcium sulphate and other salts formed by the action of the sulphuric acid. The films have a higher viscosity and a lower surface tension than is possessed by the bulk of the liquid. The sulphides move into the bubble films because the system composed of sulphide and this contaminated layer has a lower potential energy than the system composed of the pulp in the bulk of the liquid. The writers at first suspected that the selective action in this case might be due to preferential gas adsorption at the gas-sulphide contact, as opposed to a gas-gangue contact, but microscopic examination of mineral froths collected from the process showed that the solid particles in the froth were completely within the films and at no point in contact with gas. The persistence of the froth is due to the factors explained in connection with the other froth processes.

While the writers have made no appeal to electrostatic

forces or to colloidal phenomena in this discussion, they realize that the potential energy existing at the contact of dissimilar substances may well include electrical forces and that migration of the suspended solid particles under the influence of electrical charges, similar to the migration of colloids, may account for some of the selective action of the bubble films. But the agitation of the pulp in the mechanical- and pneumatic-froth processes and the generation of carbon dioxide gas on carbonate particles in intimate contact with sulphides in the acid-froth process, are sufficient, in their opinion, to bring every sulphide particles into contact with a bubble film. Once in contact, the preferential adhesion of the contaminated layer to a sulphide surface in the presence of water is sufficient to account for the persistent attachment of the sulphides to the bubble films, while on the other hand, the replacement of gas or oil by water on the surface of gangue particles explains the wetting and continued immersion of the latter.

The writers have a considerable bulk of experimental data on which many of the statements in the foregoing explanation are based. These, together with the data from other experiments which are projected, and photographs of many of the phenomena mentioned, they hope to present in a later paper.

New Haven, Conn.

THE CRACKING OF PARAFFIN BASE OILS

The Time Factor and the Temperature Factor Under Pressure

By Gustav Egloff, Thomas Twomey and Robert J. Moore

(Contribution from the Havemeyer Chemical Laboratory, Columbia University, 285.)

The present communication is one of a general series in the study of the products formed from the thermal and pressure decomposition of petroleum oils. It was undertaken with a view to ascertaining the type of oils which lend themselves most readily to the formation of aromatic hydrocarbons, gasoline and unsaturateds. The temperature, pressure and the time factor in the cracking of a number of oils have been communicated elsewhere.¹ In the present paper the production of the aromatic hydrocarbons benzene, toluene and xylene; the percentage yields of gasoline and unsaturateds have been determined from a paraffin base oil under constant pressure of 150 lbs. and varying temperatures and rates of oil flow.

As the object of this communication was to follow the percentage yields of the individual aromatic hydrocarbons, the unsaturateds and gasoline from a paraffin oil it was cracked at temperatures of 400, 450, 500, 550, 600, 650, 700 and 750 degrees C. and varying rates of oil flow of 6, 12, 16, 23, 30 and 36 gallons per hour. Twenty gallons of oil was used in each experiment at constant pressure of 150 lbs. per sq. in. Care was taken in controlling the temperature and rate of oil flow as slight variations in either factor would affect quite materially the percentage composition of the end products.

THE OIL USED FOR PRODUCTION

The oil used in the following experiments was what is called in oil technology a distillate or gas oil derived from a Pennsylvania crude petroleum. Its distillation analysis was as follows:—

¹Egloff, MET. AND CHEM. ENG., 15, 125, 1916; Egloff, Twomey and Moore, *Jour. Ind. Eng. Chem.*, 8, Nov., 1916; Egloff and Twomey, *Jour. Phys. Chem.*, 20, 597, 1916; Rüttman and co-workers, U. S. Bureau of Mines, Bulletin 114.

Temperature, Degree C	Per Cent by Volume	Specific Gravity, 15.5 Deg. C.
To 203.....	2.0	.....
200 to 250.....	7.3	0.792
250 to 300.....	57.0	0.818
300 to 350.....	28.0	0.827
Residue.....	5.5	.....
Loss.....	0.2	.....

In each experiment 20 gallons of oil was used, which was cleared of grit by a system of strainers in the oil feed line.

EXPERIMENTAL PROCEDURE

The experimental procedure consisted in passing 20 gallons of oil through a gas-heated, lap-welded steel tube of 8 inch diameter and 11.6 feet in length, set in a muffle furnace. The system was a closed one, maintained at 150 lbs. pressure, which was built up by means of a compressor using natural gas.

The temperature control between 400 degrees and 750 degrees C. was determined by means of a base-metal thermocouple which had been carefully calibrated against a platinum-iridium thermocouple and was found to be accurate within 5 degrees C plus or minus.

The rate of flow of the oil into the heated zone of the steel tube under constant temperature and pressure was varied from 6 to 36 gallons per hour. Several oil meters were tested out as to accuracy of registering the gallons of oil passing through per unit time until one was found accurate for the purpose. Care was taken in selecting the oil meter, due to the importance of the time factor in thermal and pressure decomposition of hydrocarbon oils.

The pressure of 150 lbs. per sq. inch was maintained constant by a control valve which allowed the gas in excess of the stipulated pressure to pass through a scrubbing system. This scrubbed gas was passed into the gas line to be utilized in heating the furnace.

An average sample of the gas analyzed is as follows:

ANALYSIS OF GAS		Per Cent by Volume
Unsaturated hydrocarbons.....	19.5	
Benzene.....	0.9	
Oxygen.....	0.4	
Carbon monoxide.....	0.1	
Carbon dioxide.....	0.2	
Methane.....	61.0	
Ethane.....	6.4	
Hydrogen.....	11.4	

The heating value in British thermal units of a number of gas analyses ranged between 1000 and 1400.

ANALYSES OF THE CRACKED OILS

The cracked oils recovered from the condensers were carefully filtered, due to the varying amounts of suspended carbon being present. The carbon if not removed would have yielded specific gravity values too high due to same adhering to the sides of the Westphal plummet. The analysis of the oil for benzene, toluene and xylenes was conducted according to a method already given.³ The gasoline was determined as the cuts to 150 degrees C. The unsaturateds were analyzed as the amount absorbed by concentrated sulphuric acid, the details of the method used have already been given.³

EXPERIMENTAL DATA

The data and discussion with tables are given under the following subdivisions:

A. The percentage and specific gravity of the oils recovered at various temperatures and rates of flow.

B. The distillation analysis of the recovered oils.

C. The percentage of unsaturateds in the distillation cuts of the recovered oils.

³Rittman, Twomey and Egloff, MET. AND CHEM. ENG., 13, 632, 1915.

³Egloff and Twomey, MET. AND CHEM. ENG., 14, 247, 1916.

D. The percentages of benzene, toluene and xylenes in the recovered oils.

E. The percentages of benzene, toluene and xylenes on the basis of oil used for production.

F. The total percentages of aromatics (benzene, toluene and xylene) on basis of oil used.

G. The gasoline formation in the recovered oil and the specific gravity of the gasoline.

H. Gasoline on basis of oil used for production.

I. Percentage of olefins in the gasoline.

A. THE PERCENTAGE AND SPECIFIC GRAVITY OF OILS RECOVERED AT VARIOUS TEMPERATURES AND RATES OF FLOW

TABLE I		
RATE 6 GALLONS PER HOUR		
Temperature, Deg. C.	Per Cent Recovered	Specific Gravity
400	86.0	0.857
450	49.3	0.940
RATE 12 GALLONS PER HOUR		
450	78.0	0.887
500	75.0	0.901
550	45.2	0.972
600	33.9	0.981
650	17.5	0.978
RATE 16 GALLONS PER HOUR		
450	82.6	0.855
550	38.0	0.905
600	46.5	0.945
650	29.7	0.966
RATE 23 GALLONS PER HOUR		
450	93.6	0.852
500	81.3	0.864
550	61.8	0.865
600	51.8	0.890
650	44.8	0.949
700	33.3	0.989
RATE 30 GALLONS PER HOUR		
500	90.0	0.862
550	69.5	0.872
600	63.0	0.882
650	53.3	0.895
700	46.0	0.931
750	38.4	0.952
RATE 36 GALLONS PER HOUR		
500	91.0	0.851
550	78.0	0.856
600	71.2	0.886
700	55.5	0.914
750	42.3	0.950

TABLE II—THE PER CENTS OF OILS RECOVERED AT VARYING TEMPERATURES AND RATES OF OIL FLOW

Rate, gals. per hr.	6	12	16	23	30	36
Temperature, Deg. C	PER CENTS BY VOLUME					
400	86.0	.....	.....	.....	.....	.....
450	49.3	78.0	82.6	93.6	.....	.....
500	.....	75.0	.....	81.3	90.0	91.0
550	.....	45.2	58.0	61.8	69.5	78.0
600	.....	33.9	46.5	51.8	63.0	71.2
650	.....	17.5	29.7	44.8	53.3	.....
700	.....	.....	.....	33.3	46.0	55.5
750	.....	.....	.....	.....	38.4	42.3

TABLE III—THE SPECIFIC GRAVITY OF THE RECOVERED OILS AT VARYING TEMPERATURES AND RATES OF OIL FLOW

Rate, gals. per hr.	6	12	16	23	30	36
Temperature, Deg. C	SPECIFIC GRAVITIES					
400	0.857	.....	.....	.....	.....	.....
450	0.940	0.887	0.855	0.852	.....	.....
500	.....	0.901	.....	0.864	0.862	0.851
550	.....	0.972	0.905	0.865	0.872	0.856
600	.....	0.981	0.945	0.890	0.882	0.886
650	.....	0.978	0.966	0.949	0.895	.....
700	.....	.....	.....	0.989	0.931	0.914
750	.....	.....	.....	.....	0.952	0.950

The rate of oil flow evinced the same tendencies as has been shown with other oils, namely, that with increase of rate of flow, i. e., with lessening the time of reaction, there was an increase in the amount of oil recovered. This is naturally to be expected since it follows well known physical laws. The oil, therefore, run at 36 gallons per hour showed for the temperature of 500 deg. C. a recovery of 91.0 per cent of the original, while the oil run at one-sixth that speed showed a recovery of only 49.3 per cent even at a lower cracking temperature.

A great difference in the chemical changes undergone would be expected from varying merely this one factor, and emphasis is again given to the importance of factor control in gas cracking where, besides this important time factor, we have the variables of temperature and pressure to consider.

Another factor of importance is that of concentration in cases where partial pressures of different gases admixed are taken into consideration. With these variables and their importance in mind, then, it can readily be seen what a vast field of experimentation is open, involving their use before the value of any oil can be definitely determined. There, again, the starting oil furnishes in a sense another factor for experimental consideration.

Since decrease in the time factor (increase in rate of flow) showed marked differences in recovered oil, a maximum and minimum soon showed themselves, above which and below which it was not practical to work. For instance, the higher temperature runs at the lowest rate of flow were discontinued owing to small percentage of oil recovered. Here sufficient time had been given the reaction to go largely to carbon and gas, and although good yields of products might be obtained from the recovered oil, yet calculated upon the basis of oil used these percentages would be small.

Further, the runs below 500 degrees C. at the two highest speeds were also discontinued, but owing to the slight amount of change in the recovered oil, although the amount recovered was over 90 per cent of the starting oil.

The temperature factor exercised the importance usually manifested in hydrocarbon work. With increase in cracking temperature there resulted a marked decrease in the amount of oil recovered, meaning that greater decomposition had taken place. Here, again, as in fixing the rate of flow, operating conditions had to be confined between limits giving on the one hand minimum change with high percentage recovery and on the other maximum change with low percentage recovery. As would be expected the temperature factor was much more important at the lower rates of oil flow. From Table II. it can be seen that a temperature change of 50 deg. C. at 6 gallons per hour exercised as much control over the percentage recovered as a change of about 200 deg. C. at 36 gallons per hour.

Table III. shows an increase in the specific gravity of the recovered oil with increase in cracking temperature; and also for each temperature used a decrease in specific gravity with increase in rate of oil flow. This again checks other percentage recovery figures in showing less chemical change at increased speed. With further increase of speed the oil recovered would approach 100 per cent and its specific gravity that of the starting oil.

The distillation analyses of the recovered oils are given in Table IV. and their specific gravities in Table V. From comparisons of these two tables information may be drawn as to the relative amounts of aromatics and paraffin in any one cut. For instance, the cut to 95 degrees C. of the 650 deg. run at 12 gallons per hour shows a specific gravity of 0.876, meaning almost

B. THE DISTILLATION ANALYSIS OF THE RECOVERED OILS
TABLE IV

RATE 6 GALLONS PER HOUR		
Temperature, Deg. C.	400	450
PERCENTAGE BY VOLUME		
To 95.....	7.9	9.0
95 to 120.....	4.9	8.2
120 to 150.....	5.0	7.4
150 to 170.....	5.5	5.6
170 to 230.....	7.8	9.1
230 to 270.....	28.3	19.3
270 to pitch.....	19.2	16.3
Pitch.....	21.4	25.1

RATE 12 GALLONS PER HOUR					
Temperature, Deg. C.	450	500	550	600	650
PERCENTAGE BY VOLUME					
To 95.....	7.7	8.7	13.3	18.9	26.6
95 to 120.....	4.8	6.6	9.3	10.4	12.3
120 to 150.....	4.9	5.7	6.1	4.9	3.3
150 to 170.....	5.4	5.5	4.8	2.1	1.1
170 to 230.....	9.3	8.6	11.9	7.6	10.1
230 to 270.....	27.6	20.6	11.7	10.5	15.9
270 to pitch.....	28.6	24.4	13.3	9.4	4.9
Pitch.....	11.7	19.9	29.6	36.2	25.8

RATE 16 GALLONS PER HOUR					
To 95.....	8.6	.....	12.1	16.0	24.0
95 to 120.....	7.2	.....	9.4	10.7	14.1
120 to 150.....	6.2	.....	6.6	8.1	5.9
150 to 170.....	4.6	.....	6.3	5.5	0.7
170 to 230.....	7.4	.....	9.9	8.4	11.0
230 to 270.....	25.6	.....	18.9	15.4	13.1
270 to pitch.....	20.7	.....	15.3	11.2	8.9
Pitch.....	19.7	.....	21.5	24.7	22.3

RATE 23 GALLONS PER HOUR							
Temperature, Deg. C.	450	500	550	600	650	700	750
To 95.....	3.4	8.1	11.2	12.1	14.0	21.5	.....
95 to 120.....	2.6	4.7	5.7	7.4	10.8	10.4	.....
120 to 150.....	3.5	5.4	5.5	4.7	5.7	4.6	.....
150 to 170.....	3.6	5.5	6.2	5.8	4.8	1.2	.....
170 to 230.....	10.6	16.4	14.3	16.4	7.8	9.5	.....
230 to 270.....	31.0	29.0	17.9	18.3	24.3	14.0	.....
270 to pitch.....	37.0	17.5	22.2	17.3	8.3	12.1	.....
Pitch.....	8.3	13.4	17.0	18.0	24.3	26.7	.....

RATE 30 GALLONS PER HOUR							
To 95.....	.....	8.4	10.0	11.2	12.1	15.4	18.9
95 to 120.....	.....	6.8	8.0	8.2	8.0	7.4	12.7
120 to 150.....	.....	6.6	6.4	6.5	6.0	5.7	7.1
150 to 170.....	.....	6.6	5.7	5.1	6.8	5.7	5.0
170 to 230.....	.....	8.7	11.3	9.8	10.5	15.5	11.1
230 to 270.....	.....	23.0	25.6	19.3	18.5	18.5	16.2
270 to pitch.....	.....	23.5	16.8	17.4	16.1	9.6	5.8
Pitch.....	.....	16.4	16.2	22.5	22.0	22.2	22.8

RATE 36 GALLONS PER HOUR							
To 95.....	.....	5.3	7.4	11.2	.....	14.8	16.1
95 to 120.....	.....	4.0	4.9	7.1	.....	8.4	11.7
120 to 150.....	.....	4.9	4.0	6.2	.....	7.3	7.7
150 to 170.....	.....	3.7	6.0	6.3	.....	7.5	5.3
170 to 230.....	.....	7.3	10.7	9.8	.....	9.0	15.8
230 to 270.....	.....	35.2	29.4	24.2	.....	21.6	13.9
270 to pitch.....	.....	23.8	19.9	16.1	.....	12.8	5.9
Pitch.....	.....	15.8	17.7	19.1	.....	18.6	23.6

TABLE V—THE SPECIFIC GRAVITIES OF THE DISTILLATION CUTS OF THE RECOVERED OILS

RATE 6 GALLONS PER HOUR		
Temperature, Deg. C.	400 Deg. C. Run	450 Deg. C. Run
To 95.....	0.718	0.787
95 to 120.....	0.787	0.846
120 to 150.....	0.801	0.855
150 to 170.....	0.824	0.875
170 to 230.....	0.854	0.905
230 to 270.....	0.867	0.943
270 to pitch.....	0.879	0.982

RATE 12 GALLONS PER HOUR

Temperature, Deg. C.	470	500	550	600	650
To 95.....	0.718	0.734	0.815	0.861	0.876
95 to 120.....	0.784	0.798	0.860	0.862	0.872
120 to 150.....	0.800	0.813	0.862	0.862	0.871
150 to 170.....	0.820	0.833	0.872	0.872	0.876
170 to 230.....	0.853	0.859	0.951	.....	.....
230 to 270.....	0.875	0.881	0.972	.....	.....
270 to pitch.....	0.884	0.896	1.002	.....	.....

RATE 16 GALLONS PER HOUR

Temperature, Deg. C.	450	550	600	650
To 95.....	0.728	0.756	0.809	0.868
95 to 120.....	0.798	0.823	0.852	0.867
120 to 150.....	0.810	0.837	0.860	0.869
150 to 170.....	0.820	0.847	0.870	0.879
170 to 230.....	0.867	0.898	0.938	.....
230 to 270.....	0.886	0.926	0.971	.....
270 to pitch.....	0.904	0.957	1.003	.....

RATE 23 GALLONS PER HOUR

Temperature, Deg. C.	450	500	550	600	650	700
To 95.....	0.714	0.726	0.728	0.743	0.814	0.866
95 to 120.....	0.772	0.788	0.793	0.812	0.848	0.865
120 to 150.....	0.790	0.802	0.806	0.824	0.852	0.868
150 to 170.....	0.800	0.812	0.816	0.834	0.862	0.878
170 to 230.....	0.831	0.849	0.866	0.881	0.923	.....
230 to 270.....	0.845	0.874	0.885	0.906	0.954	.....
270 to pitch.....	0.856	0.881	0.896	0.935	0.995	.....

RATE 30 GALLONS PER HOUR

Temperature, Deg. C.	500	550	600	650	700	750
To 95.....	0.717	0.732	0.751	0.756	0.842	0.845
95 to 120.....	0.774	0.797	0.810	0.815	0.858	0.865
120 to 150.....	0.778	0.813	0.820	0.823	0.860	0.866
150 to 170.....	0.788	0.823	0.830	0.833	0.870	0.870
170 to 230.....	0.843	0.861	0.872	0.891	0.941	.....
230 to 270.....	0.855	0.885	0.892	0.905	0.978	.....
270 to pitch.....	0.871	0.901	0.913	0.930	1.016	.....

RATE 36 GALLONS PER HOUR

Temperature, Deg. C.	500	550	600	700	750
To 95.....	0.716	0.718	0.745	0.782	0.851
95 to 120.....	0.776	0.781	0.812	0.835	0.858
120 to 150.....	0.796	0.797	0.821	0.841	0.858
150 to 170.....	0.806	0.808	0.831	0.851	0.868
170 to 230.....	0.826	0.848	0.875	0.902	.....
230 to 270.....	0.855	0.862	0.897	0.930	.....
270 to pitch.....	0.865	0.872	0.907	0.962	.....

pure benzene. The volume of this cut is 26.6 per cent of the entire oil recovered from the run. Using the same 12 gallons per hour table and tracing the formation across to the columns of lower temperature runs we find that the specific gravity falls off markedly, indicating low boiling paraffin formation, the volume of the cut decreasing at the same time to 7.7 per cent.

Criss-cross comparisons of this nature make these tables extremely important in following the trend of the reactions. For instance, using again the columns just referred to, we find that while the cut to 95 deg. C. has increased in volume to 26.6 per cent with increase in temperature of cracking, the cut 150 deg. to 170 deg. C. has decreased to 1.1 per cent at the same time. We may, therefore, infer that the benzene has formed at the expense of the higher boiling point hydrocarbons.

A chain of reasoning can then be followed through the entire distillation analysis throwing much light upon just what has occurred and information is obtained as to controlling the factors of temperature and time for producing better yields of whatever hydrocarbons are desired.

The percentage of unsaturateds in the distillation

C THE PER CENT OF UNSATURATEDS IN THE DISTILLATION CUTS OF THE RECOVERED OILS

TABLE VI

RATE 6 GALLONS PER HOUR

Temperature, Deg. C.	400	450
PER CENT BY VOLUME		
To 95.....	32	28
95 to 120.....	28	17
120 to 150.....	25	16
150 to 170.....	31	35
170 to 230.....	14	16
230 to 270.....	12	17
270 to pitch.....	12	21

RATE 12 GALLONS PER HOUR

Temperature, Deg. C.	450	500	550	600	650
To 95.....	40	52	23	11	6
95 to 120.....	22	20	10	9	4
120 to 150.....	17	19	12	12	11
150 to 170.....	23	34	..	..	..
170 to 230.....	14	15	13	..	..
230 to 270.....	12	13	18	10	16
270 to pitch.....	13	14	27	21	6

RATE 16 GALLONS PER HOUR

Temperature, Deg. C.	450	500	550	600	650	700
To 95.....	39	..	26	25	9	..
95 to 120.....	20	..	19	9	8	..
120 to 150.....	17	..	19	15	10	..
150 to 170.....	23	..	..	..	..	..
170 to 230.....	16	..	17	13	..	..
230 to 270.....	16	..	22	16	14	..
270 to pitch.....	14	..	30	21	20	..

RATE 23 GALLONS PER HOUR

Temperature, Deg. C.	450	500	550	600	650	700
PER CENT BY VOLUME						
To 95.....	37	44	46	43	23	9
95 to 120.....	20	20	23	18	15	7
120 to 150.....	22	19	23	23	16	26
150 to 170.....	23	32	61	33	35	94
170 to 230.....	59	15	16	18	14	40
230 to 270.....	9	11	13	16	18	36
270 to pitch.....	8	11	15	20	25	20

RATE 30 GALLONS PER HOUR

Temperature, Deg. C.	500	550	600	650	700	750
To 95.....	47	42	36	32	12	12
95 to 120.....	24	19	19	22	9	11
120 to 150.....	25	21	18	16	13	11
150 to 170.....	27	28	45	31	95	34
170 to 230.....	14	18	15	15	15	13
230 to 270.....	12	15	14	14	15	12
270 to pitch.....	11	17	18	17	27	22

RATE 36 GALLONS PER HOUR

Temperature, Deg. C.	500	550	600	650	700	750
To 95.....	44	47	35	..	29	14
95 to 120.....	22	27	22	..	17	8
120 to 150.....	23	17	27	..	20	15
150 to 170.....	27	26	38	..	40	23
170 to 230.....	12	12	16	..	17	10
230 to 270.....	10	10	13	..	18	15
270 to pitch.....	9	10	15	..	23	26

cuts varied, dependent upon the cut, from a minimum of 4 per cent to a maximum of 95 per cent. The greatest average percentage formation of olefins occurred in the benzene cut to 95 deg. C., which would indicate a relatively high percentage formation of the amylenes, hexylenes and heptylenes. Low temperature and high rates of oil flow are conducive to unsaturated hydrocarbon formation. With increase of the cracking temperature, the percentage formation of unsaturateds falls off toward a minimum. Likewise with increase of the time factor, the unsaturateds approach a minimum.

The formation of the aromatic hydrocarbons benzene, toluene, and xylene, due to thermal and time factor-effects, from a paraffin base oil is clearly brought out by this table, in the recovered oil.

D. THE PER CENT OF BENZENE, TOLUENE AND XYLENE IN THE RECOVERED OILS

TABLE VII

Rate, gals. per hr.	6	12	16	23	30	36
Temperature, Deg. C.	PER CENT BENZENE BY VOLUME					
400	0.0	....	....	....	....	....
450	3.8	0.0	0.4	0.0	....	....
500	....	1.3	....	0.3	0.0	0.0
550	....	7.9	2.1	0.4	0.8	0.0
600	....	12.2	8.9	1.7	1.2	1.7
650	....	26.3	22.3	8.3	2.3	....
700	....	....	....	18.7	11.8	5.8
750	....	....	....	....	14.8	13.7
PER CENT TOLUENE BY VOLUME						
400	1.8	....	....	....	....	....
450	6.3	1.8	3.5	0.6	....	....
500	....	3.2	....	2.0	2.1	1.0
550	....	8.6	6.4	2.5	3.7	1.8
600	....	7.9	9.4	4.4	3.2	4.2
650	....	12.3	13.8	9.2	4.5	....
700	....	....	....	9.5	6.7	6.3
750	....	....	....	....	11.5	10.6
PER CENT XYLENE BY VOLUME						
400	1.9	....	....	....	....	....
450	6.4	1.7	2.8	0.9	....	....
500	....	2.7	....	2.0	1.1	1.6
550	....	5.7	4.6	2.2	3.1	1.4
600	....	3.3	7.4	2.6	2.9	3.4
650	....	3.3	5.9	4.9	3.2	....
700	....	....	....	4.5	5.1	5.4
750	....	....	....	....	6.5	5.7

The formation of benzene from a paraffin base oil is a function of temperature, pressure, time factor and catalysis. In the particular oil used in this series of experiments the critical temperature of benzene formation occurred between 400 deg. and 450 deg. C. and rate of oil flow of 6 gal. per hour or 1 gal. of oil vaporized in the cracking area, 10 minutes, at 150 lb. pressure.

This formation holds only for the critical temperature when the rate is 6 gal. per hour. With change of rate of oil flow a change necessarily must be made in the temperature for benzene formation. As the rate of oil flow is increased the temperature of benzene formation increases from 450 deg. C. at 6 gal. per hour to 600 deg. C. and 36 gal. per hour.

The effect of the time factor is emphasized particularly in the benzene formation figures. The tables show that benzene is formed in appreciable quantities at 450 deg. C. at a rate of 6 gal. per hour. But, if the rate is increased to 36 gal. per hour, to form benzene the temperature must be raised 150 deg. higher than for the slower rate.

When the rate of oil flow is held constant and the temperature is increased the percent of benzene in the recovered oil increases to a maximum in each case. The maximum percentage 26.3 of benzene occurred at 12 gal. per hour and 650 deg. C. in the recovered oil. For corresponding rate of oil flow toluene and xylene form at lower temperatures than does benzene, without exception.

This phenomenon has added experimental evidence as to the formation of the higher methyl derivatives of benzene occurring first when paraffin base oils are subjected to cracking. This is in accord with experimental work upon the pure aromatic hydrocarbons benzene, toluene and xylenes.⁴ Subjecting the xylenes to cracking conditions the reaction products resulting gave toluene, benzene, naphthalene and anthracene, carbon and gas. Toluene gave similar products with some formation of higher methyl derivatives. Benzene formed methyl derivatives to only a very slight extent going mainly to diphenyl and polycyclic hydrocarbons.

The maximum of 7.4 per cent formation of xylene oc-

curred at 600 deg. C. and 16 gal. per hour and for toluene 13.8 per cent under the same conditions. In general increase of temperature increased the percentage formation of toluene, while for xylene the percentage increased to a maximum and then decreased with increase of temperature. At constant temperatures increase of the time factor gave a maximum of toluene and xylene and then a decrease.

E. THE PERCENTAGES OF BENZENE, TOLUENE AND XYLENE ON THE BASIS OF OIL USED FOR PRODUCTION

TABLE VIII

Rate, gals. per hr.	6	12	16	23	30	36
Temperature, Deg. C.	PER CENT BENZENE BY VOLUME					
400	0.0	....	....	....	....	....
450	1.4	0.0	0.3	0.0	....	....
500	....	1.0	....	0.2	0.0	0.0
550	....	3.6	1.6	0.3	0.6	0.0
600	....	4.2	4.1	0.9	0.8	1.2
650	....	4.6	6.6	3.7	1.2	....
700	....	....	....	6.2	5.4	3.2
750	....	....	....	....	5.7	5.8
PER CENT TOLUENE BY VOLUME						
400	1.5	....	....	....	....	....
450	3.1	1.4	2.9	0.5	....	....
500	....	2.4	....	1.6	1.8	0.9
550	....	3.9	3.7	1.5	2.5	1.4
600	....	2.7	4.4	2.3	2.0	3.0
650	....	2.2	4.1	4.1	2.4	....
700	....	....	....	3.2	3.1	3.5
750	....	....	....	....	4.4	4.5
PER CENT XYLENE BY VOLUME						
400	1.6	....	....	....	....	....
450	3.2	1.3	2.3	0.8	....	....
500	....	2.0	....	1.6	1.0	1.4
550	....	2.6	2.6	1.4	2.2	1.1
600	....	1.1	3.4	1.3	1.8	2.4
650	....	0.6	1.8	2.4	1.7	....
700	....	....	....	1.5	2.3	3.0
750	....	....	....	....	2.5	2.4

The percentage yield of benzene on the basis of oil used for production at constant rate of oil flow increased with increase of temperature. The maximum yield of 6.6 per cent of benzene was found to occur at 650 deg. C. and 16 gal. per hour. In general the formation of benzene decreased with increase of the rate of oil flow at constant temperature. Within the temperature limits of the experiments 400 deg. to 750 deg. C., benzene increased with increase of temperature at constant rate.

The formation of toluene and xylene reached a maximum with increase of temperature at constant rate and then decreased. The maximum percentage yield of toluene of 4.5 was obtained at 750 deg. C. and 36 gal. per hour and for xylene 3.4 per cent at 600 deg. C. and 16 gal. per hour.

One of the significant points in the above data lies in the fact that benzene, toluene and xylene form, at the low temperatures of 400 deg. and 450 deg. C., from a paraffin base oil having a boiling point range lying between 200 deg. and 350 deg. C. Their formation cannot be ascribed entirely to the possible presence in the starting oil of the phenyl radical. The low specific gravity and sulphonation of the distillation cuts of the starting oils indicate practically pure paraffin hydrocarbons, no aromatic, and possibly small traces of naphthene present. This brings the question of the mechanism of the reaction in forming benzene, toluene and xylene from acetylene, crotonylene, ethylene, propylene, butylene or amylene, which may have been formed at these low temperatures from the paraffin oil.

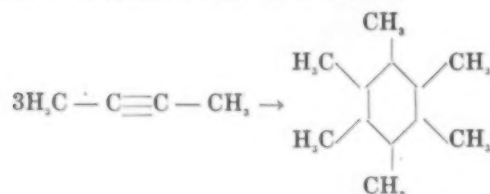
It is questionable as to whether acetylene or crotonylene form at 400 deg. or 450 deg. C. from a paraffin base oil of high boiling point range. These two hydrocarbons have been isolated from high temperature de-

⁴Rittman, Egloff and Byron, *Jour. Ind. Eng. Chem.*, 7, 1019, 1915.

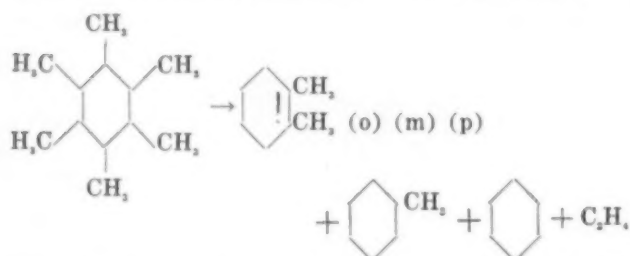
composition of paraffin oils. No one as far as we know has isolated acetylene or crotonylene from low temperature decomposition of paraffin oils. Experimentally it has been determined that acetylene forms benzene according to the following reaction



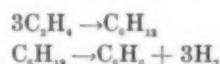
taking crotonylene therefore as one of the products of the reaction its course would be as follows:⁴



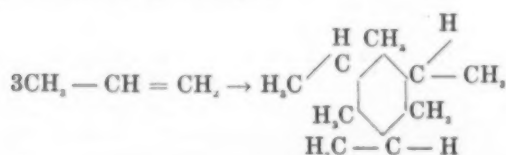
which would form hexamethyl benzene. This in turn decomposing into the lower methyl derivatives of benzene and forming ethylene which is usually formed in large amounts in hydrocarbon decomposition work.



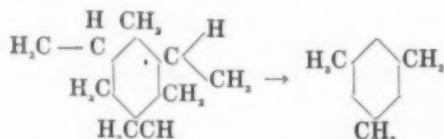
The ethylene formed polymerizing to form hexahydrobenzene—which decomposes at low temperature to form benzene.⁵



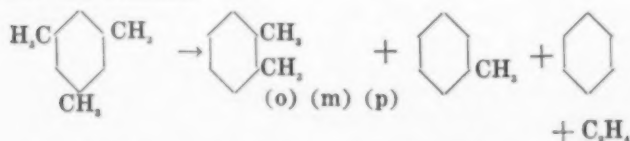
Decomposing three molecules of pyropylylene the following reaction may take place:



forming the saturated naphthene hydrocarbon hexahydro-mesitylene. This compound could readily split off hydrogen forming mesitylene.



Mesitylene can in turn decompose to form xylene, toluene and benzene.



The total percentage of benzene, toluene and xylene upon the basis of oil used increased with increase of temperature at constant rate of oil flow. The maximum formation of 12.7 per cent occurred at 750 deg. C. and 36 gal. per hour. At constant temperature in general the percentage formation of total aromatics decreased

⁴Crotonylene with sulphuric acid is polymerized forming hexamethyl benzene.

⁵Sabatier and Senderen, Am. Chim. Phys., 8, 4, 458, 1905; Zelinsky, Berichte, 44, 3121, 1911.

F. THE TOTAL PER CENT AROMATICS (BENZENE, TOLUENE AND XYLENE) ON BASIS OIL USED

Rate, gals. per hr. . . .	6	12	16	23	30	36
Temperature, Deg. C.	PER CENT BY VOLUME					
400	3.1	...	...	1.3	...	...
450	7.7	2.7	5.5	...	...	...
500	...	5.4	...	3.4	2.8	2.3
550	...	10.1	7.9	3.2	5.3	2.5
600	...	8.0	11.9	4.5	4.6	6.6
650	...	7.4	12.5	10.2	5.3	...
700	...	...	...	10.9	10.8	9.7
750	...	...	...	...	12.6	12.7

with increase of the rate of oil flow. It is to be expected that with increase of temperature the formation of cyclic hydrocarbons of the benzene series would increase due to their greater stability in comparison with the long chained paraffin hydrocarbons of the starting oil, at the increased temperatures.

The formation of gasoline in the recovered oil ranged from a minimum of 14.2 to a maximum of 44 per cent. The specific gravity of the gasoline cut to 150 deg. C.

G. THE GASOLINE FORMATION IN THE RECOVERED OILS AND THE GASOLINE SPECIFIC GRAVITIES. (TABLES X, XI AND XII)

RATE 6 GALLONS PER HOUR		
Temperature, Deg. C.	Per Cent Gasoline	Specific Gravity
400	17.8	0.756
450	24.6	0.812
RATE 12 GALLONS PER HOUR		
450	17.4	0.760
500	21.0	0.772
550	28.7	0.831
600	34.2	0.861
650	42.2	0.874
RATE 16 GALLONS PER HOUR		
450	22.0	0.763
500	28.1	0.797
600	34.8	0.820
650	44.0	0.867
RATE 23 GALLONS PER HOUR		
450	9.5	0.759
500	18.2	0.752
550	22.4	0.766
600	24.2	0.781
650	30.5	0.835
700	36.5	0.866
RATE 30 GALLONS PER HOUR		
500	21.8	0.753
550	24.4	0.774
600	25.9	0.787
650	26.1	0.789
700	28.5	0.842
750	39.1	0.851
RATE 36 GALLONS PER HOUR		
500	14.2	0.753
550	16.3	0.758
600	24.5	0.776
700	30.5	0.804
750	35.5	0.854

TABLE XI—PERCENTAGE OF GASOLINE IN RECOVERED OILS

Rates of flow	6	12	16	23	30	36
Temperature, Deg. C. of Run						
400	17.8	...	...	...	...	...
450	24.6	17.4	22.0	9.5	...	...
500	...	21.0	...	18.2	21.8	14.2
550	...	28.7	28.1	22.4	24.4	16.3
600	...	34.2	34.8	24.2	25.9	24.5
650	...	42.2	44.0	30.5	26.1	...
700	...	...	...	36.5	28.5	30.5
750	...	...	...	...	39.1	35.5

TABLE XII—SPECIFIC GRAVITIES OF THE GASOLINE CUTS

Rates of flow	6	12	16	23	30	36
Temperature, Deg. C. of Run						
400	0.756	.....	.....	.....	.....	.....
450	0.812	0.760	0.763	0.759	.....	.....
500	.....	0.772	.....	0.752	0.753	0.753
550	.....	0.831	0.797	0.766	0.774	0.758
600	.....	0.861	0.820	0.781	0.787	0.776
650	.....	0.874	0.867	0.835	0.780	.....
700	.....	.....	.....	0.806	0.842	0.804
750	.....	.....	.....	.....	0.851	0.854

ranged between 0.756 and 0.874. The gasoline or motor fuel from thermolizing a paraffin base oil is a mixture of paraffins, olefins and aromatic hydrocarbons and the specific gravity must necessarily be higher than if simply paraffins were present. The percentage of hydrocarbons boiling below 150 deg. C. increases with increase of temperature as does also the specific gravity. With increase of the rate of oil flow, the percentage usually reaches a maximum and then decreases as does also the specific gravity values.

H. GASOLINE ON BASIS OIL USED FOR PRODUCTION
TABLE XIII

Rate, gals. per hr. . . .	6	12	16	23	30	36
Temperature, Deg. C.	PERCENTAGE GASOLINE					
400	15.4	.....	.....	.....	.....	.....
450	12.2	13.4	18.1	8.8	.....	.....
500	.....	15.7	.....	14.8	18.1	12.9
550	.....	12.9	16.3	13.9	17.1	13.0
600	.....	12.0	16.2	12.6	16.3	17.8
650	.....	7.1	13.1	13.5	13.9	.....
700	.....	.....	.....	11.6	13.9	16.9
750	.....	.....	.....	.....	15.4	14.9

The maximum percentage formation of gasoline from the paraffin base oil used was 18.1 at 450 deg. C. and 16 gal. per hour and also the same per cent at 500 deg. C. and 30 gal. per hour. This emphasizes the close relationship of the temperature and rate of oil flow. By increasing the temperature 50 deg. C. almost double the amount of oil could be cracked in the same time to form gasoline.

I. PERCENTAGE OF OLEFINS IN THE GASOLINE CUT
TABLE XIV

Rate, gals. per hr. . . .	6	12	16	23	30	36
Temperature, Deg. C.	PER CENT BY VOLUME					
400	29.2	.....	.....	.....	.....	.....
450	19.6	28.6	26.9	27.1	.....	.....
500	.....	33.1	.....	22.3	33.0	30.5
550	.....	15.8	22.2	34.4	29.0	33.0
600	.....	10.5	18.0	31.5	26.2	29.1
650	.....	5.8	8.7	18.2	25.0	.....
700	.....	.....	.....	9.9	11.4	24.0
750	.....	.....	.....	.....	11.3	12.2

Table XIV tabulates the percentage of olefins in the various gasolines obtained. These values are important in determining the amount of refining necessary to purify the motor fuel, sulphuric acid being usually used for that purpose.

SUMMARY

1. A paraffin base oil was subjected to temperatures ranging between 400 deg. and 750 deg. C. and rates of oil flow from 6 to 36 gal. per hour at 150 lb. per square inch.
2. The percentages of unsaturateds in the distillation cuts of the cracked oils were determined. These cuts were as follows: To 95 deg. C.; 95 to 120 deg. C.; 120 to 150 deg. C.; 150 to 170 deg. C.; 170 to 230 deg. C.; 230 to 270 deg. C.; 270 to pitch.
3. It is important to note the low temperature of

400 deg. C. for the formation of toluene and xylene from a paraffin base oil which had a boiling point range of 95 per cent between 200 deg. and 350 deg. C. The temperature of cracking was but slightly above the highest boiling point constituent of the starting oil. Benzene formed to the extent of 3.8 per cent in the recovered oil at 450 deg. C. and rate of oil flow of 6 gal. per hour.

4. A hypothetical mechanism of aromatic hydrocarbon formation from the decomposition products of the paraffin oil has been given.

5. The maximum percentage of 6.6 for benzene on the basis of oil used occurred at 650 deg. C. and 16 gal. per hour. For toluene the percentage of 4.5 at 750 deg. and 36 gal. per hour and for xylene 3.4 per cent as a maximum occurred at 600 deg. C. and 16 gal. per hour.

6. The maximum percentage of 18.1 for gasoline formation on basis of oil used occurred at 450 deg. C. and 16 gal. per hour and also at 500 deg. C. and 30 gal. per hour. That is, by increasing the temperature 50 deg. the capacity factor increased almost 100 per cent.

7. The percentage of olefins in the gasoline cut ranged between 5.8 and 34.4.

8. The maximum percentage formation of the total aromatic hydrocarbons benzene, toluene and xylene of 12.7 on the basis of oil used was found at 750 deg. C. and 36 gal. per hour.

9. Since, as stated in the introduction, one of the objects to be ascertained in this paper was the relative value of different hydrocarbons for the formation of gasoline, unsaturateds and aromatics the results obtained from a naphthene base oil in a previous investigation have been compared. The naphthene base oil run under comparable conditions yielded uniformly higher percentages of end products as shown in the following table, giving maximum yield conditions of the two type oils:

Egloff, Twomey and Moore, MET. AND CHEM. ENG., 15, 387, 1916.

	NAPHTHENE OIL		PARAFFIN OIL	
	Per Cent by Volume	Temperature of Run, Deg. C.	Per Cent by Volume	Temperature of Run, Deg. C.
Benzene.....	7.2	650	6.6	750
Toluene.....	6.0	650	4.5	650
Xylene.....	8.1	600	3.4	600
Total aromatics: Benzene, toluene and xylene.....	18.2	650	12.7	750
Gasoline.....	26.2	600	18.1	450
Olefins in gasoline cut.....	28.1	600	29.9	450

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Lead Output in Missouri for 1915.—In 1915 Missouri supplied the world with 36 per cent of the lead ore mined in the United States, holding first rank for an output of 160,105 tons. The total lead ore output for the year in the United States was 537,012 tons. This large output was mainly due to the great demand caused by the European war. The lead ore output for 1913 was 436,430 tons, in 1914 the United States supplied 534,482 tons, showing that the increased output for the year 1915 was 2530 tons over that of 1914 and 100,582 tons over that of 1913. The average value of lead for the year 1915 was 4.7 cents per pound or \$94 per ton. The Missouri ores also contain a small amount of silver, but it requires high-grade refining to desilverize the lead. Three Missouri smelting and refining companies now are equipped with desilverizing departments, which save the 1 per cent of silver found in the ore, which formerly was not recovered.

The Chemical and Physical Properties of Foundry Irons

By J. E. Johnson, Jr.

Irons were formerly, and to some extent still are, graded by their fracture from No. 1 to No. 6—No. 1 being the most coarse grained and graphitic iron and No. 6 being a solid white iron entirely without graphite. The No. 2 and 3 grades are nearly always divided into No. 2-X and No. 2 plain, and No. 3-X and No. 3 plain. Number 4 is commonly called "gray forge," No. 5 "mottled," and No. 6 "white," this grading corresponding with the fractures of the iron, and the fracture in turn being supposed to correspond with the softness of the iron in use.

Up to about twenty or twenty-five years ago chemical analysis was not used to any important extent in determining the quality of foundry iron, and this grading by fracture was the only method available to the foundrymen for determining the suitability of different irons for different purposes, but in more recent years it has been found that this grading corresponded in a general way with the presence of silicon and the absence of sulphur, and chemical specifications became finally to be used as supplementary to the fracture, and now to a very large extent have replaced fracture altogether in the purchase and sale of coke irons. The Eastern Pig Iron Association has adopted the following specifications as corresponding to the three grades first mentioned:

	Silicon	Sulphur
No. 1X	2.75 — 3.25	0.04
No. 2X	2.25 — 2.75	0.045
No. 2 Plain	1.75 — 2.25	0.05

The relations between chemical composition of irons and their physical characteristics are vital in foundry irons and there have been until recently wide gaps in our knowledge of the subject which are not yet completely filled but which have been greatly reduced by investigations made in recent years. In October, 1914, I delivered an address before the Franklin Institute in Philadelphia in which I embodied the latest developments of our knowledge of this subject. The principal recent development was the discovery of the important effect of oxygen on the physical qualities of the irons in which it is contained. These effects are for most purposes highly beneficial, and for others very detrimental, and they explain many facts, the reasons for which had been mysteries previous to this discovery.

Following the discovery, methods were developed for introducing oxygen artificially into iron and some of the results obtained by this process are given as a part of the subject of the quality of iron, and are included in the article above mentioned, which is quoted here practically in full.

Nearly all the chemical work and most of the microphotographs made during the investigations of which this paper is the result were made by Mr. L. Selmi, then chief chemist at the Ashland plant, now chief chemist and metallurgist of the River Furnace Company's steel plant. In addition Mr. Selmi gave his hearty and sympathetic co-operation to the whole investigation and rendered invaluable service to it throughout.

Founding is one of the early arts and undoubtedly had its origin at the time of the development of the blast furnace in the latter middle ages. It has made its greatest progress, however, since the methods of using mineral fuel in this furnace have cheapened the product of the latter so much that 90 per cent or more of that product is now nothing more than the raw material for the production of steel. The art of founding was almost ignored by the scientific metallurgist until

within comparatively few years. The developments in the manufacture of steel were so rapid and of such vast importance to the whole of mankind that practically all the labors of iron and steel metallurgists were devoted to steel, and the foundryman was left to struggle along as best he could on the basis of his hard-earned, and sometimes contradictory, practical knowledge and experience. In the nineties of the last century was brought about a great change in this condition, for chemistry began to be applied freely in the foundry, and by its aid many facts in connection with the manufacture of cast iron were brought out. Some of these facts the practical men declared were not true, and the conditions of cast-iron manufacture are so complex that many are still in dispute.

In 1900, the closing year of the decade referred to, I published in the *American Machinist* an article in which, to my mind, was made the first definite and coherent statement of the nature of cast iron, particularly in its relation to steel. The following are some quotations from this article:

... the key to the subject lies in considering cast iron and steel not as entirely separate and distinct, but as the same substance, passing by infinitesimal gradations from the chemical and physical properties of one extreme to those of the other. The probable reason that this fact is not more widely realized than it is, is that both of the extreme conditions are "soft"—soft gray iron and soft or mild steel—while the connecting link between them is the hardest of tool steel at one end and the hardest of white iron at the other, with no sharp lines separating them from one another.

There is no doubt that there could be made in a blast furnace, from the proper materials, an iron containing silicon 0.2, manganese 0.4, phosphorus, 0.03, sulphur, 0.03, combined carbon 2.75 per cent., graphitic carbon, trace.

But excessively hard crucible steel may be made having precisely the same analysis, and both have practically the same properties. The crucible steel is so hard and brittle that it cannot be commercially rolled or hammered, and is of no value, as well as being extremely difficult to make, while the greatest care and effort, and probably several weeks or even months of trial, would be necessary to produce an iron with the composition given, in a blast furnace, and when produced it would be of little commercial value; so that a material having this composition is seldom or never produced—never commercially—and we are not, therefore, familiar with it, and do not realize the fact, which it is impossible to emphasize too strongly in this connection, that it exists, or may exist, and constitutes a perfect link between cast iron and steel.

Since soft iron contains the most total carbon (about 4 per cent) and very mild steel the least (say, 0.06 per cent), while the intermediate stage, the very hard iron or steel just described, contains about the average of these two, roughly speaking, and is so much harder than either as not to resemble them in its properties, this may be thought to weaken or invalidate the above statement; but it does not, when properly considered, for, while the total carbon is high in the cast iron, almost all of it is in the graphite form and only a trace is combined.

If we say, "Cast iron and steel are alloys of the chemical element iron with carbon, with a chemical and physical admixture of other compounds, and the hardness of the alloy depends, within commercial limits, upon the amount of the carbon in it, while its tenacity, ductility, and other physical properties depend upon the other substances present, and upon the physical treatment it receives, and the variations produced by these are approximately the same in both," we shall have a blanket definition of the two substances which covers both quite fully and with substantial accuracy.

Too much stress can hardly be laid upon the two kinds of carbon in cast iron, the "combined" being chemically united or combined with the iron to form a chemical compound; the other, the graphitic, being merely interspersed among the grains or crystals of the iron. The most striking proof of this latter is that shown a few years ago, I have forgotten by whom, which consists in brushing with a steel-wire brush the fractured face of a pig of gray iron, one-half of which is protected from the action of the brush: the brushed half becomes perfectly white, like white iron, although the grain, of course, remains as before. The unbrushed half, of course, shows the contrast more plainly.

Iron, when hot, has a far higher capacity for dissolving carbon and retaining it in combination than it has when cold. The graphitic carbon is probably all in solution at first, although this is not certain. But as the iron cools, if it cools slowly, the graphite is forced out and what is near the surface flies off into the air. It can be seen doing it at a blast-furnace cast when the iron is of the proper composition. The rest is retained, immersed in the grains of the iron, and probably gives to gray cast iron whatever toughness and flexibility it possesses, separating the grains or crystals from continuous contact and lubricating their movements.

Thus hard cast iron, while much less flexible, is much more elastic than soft, as it should be, having much less graphitic carbon in it. The more slowly the iron cools the more graphite crystallizes out of it and the larger the crystals, so that comparatively hard iron, when cast into large masses and allowed to cool for several days, or longer, will show a grain which would put "No. 1 X" to the blush.

The tendency to eject carbon and become softer, in consequence, does not by any means stop when the iron is solid, nor until it is down to the lower limit of the red heat at least, and how much lower the writer will not undertake to say. When any casting was made from moderately hard iron which it was required to machine, it was always kept carefully covered up until dead cold, and this was known by experience to be very necessary. Some intentionally "chilled" pieces, when made of very hard iron, would "fly" off themselves from the cooling strains set up, but could often be saved by keeping them hot as long as possible.

When the iron is cooled suddenly, the carbon does not have time to separate out, and remains combined with the iron, making it "white" instead of gray, because of the absence of the black graphite.

I think that this is a reasonably good presentation in a broad way of our knowledge of the subject to-day. It is a matter of interest that, in the subsequent part of the above article, is to be found the statement that the only reason for the use of charcoal iron, particularly for chilling purposes, was that, charcoal being free from sulphur, iron as low in silicon as desired could be produced in the charcoal furnace without any important simultaneous increase in the sulphur above that in high silicon iron, which could not be done in coke furnaces until shortly before that time, but that it could be done then at will, and that charcoal iron had accord-

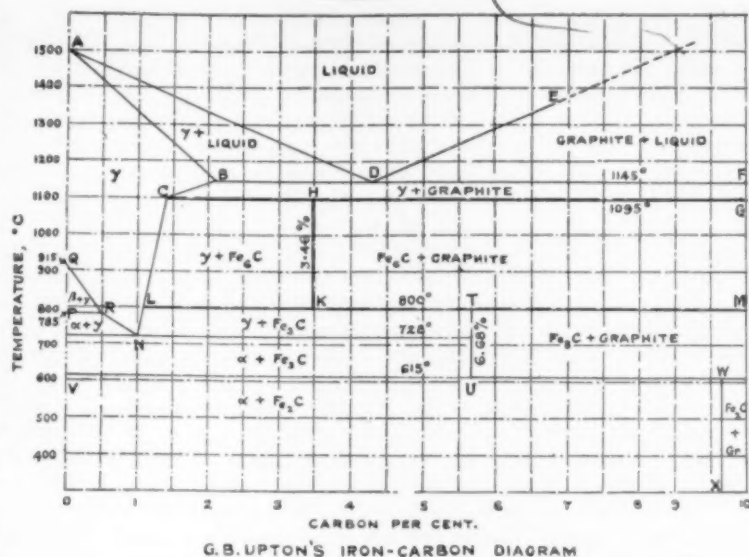


FIG. 2

ingly no advantage over coke iron, and was destined to pass out of use. This is probably as good an illustration of assuming that all the facts fit an incomplete theory and drawing a totally erroneous conclusion in consequence as you will find anywhere in technical literature, and it is my particular purpose to point out the important respect in which charcoal iron differs fundamentally from coke iron, and to describe the method by which we have succeeded in obtaining, for a modified form of coke iron, the advantages of charcoal iron in a greater degree than are obtainable by it.

In 1901, the year following the publication of my article, Prof. Henry M. Howe read a paper before the American Institute of Mining Engineers, in which the theorem of the continuity of the cast iron-steel series was set forth more elaborately and in far better language than in mine. Professor Howe pointed out that the important question in regard to the carbon in cast iron is not what is the total carbon, nor yet how much is thrown out as graphite, but how much is left combined, because it is upon the quantity of combined carbon in the matrix that its strength depends.

It seemed to me at first that this statement put the matter in a nutshell, and was obviously correct. It will be seen later that Professor Howe's is also an incomplete theory, and that certain other factors enter in of so much greater importance in the final result as almost to eclipse the truth contained in his statement taken by itself.

From the quotations I have made, it is obvious that cast iron must be considered primarily as an alloy of iron and carbon. This is quite proper in a more elementary sense, because carbon is present in iron quantitatively to a greater extent by weight and to a far greater by volume than is any other element. Carbon has, moreover, a more powerful effect, weight for weight, than any other element except one.

The Iron-Carbon Diagram

The iron-carbon diagram, as applied to cast iron by Guertler based upon researches of Wittorff, is shown in Fig. 1. In Fig. 2 is shown a similar diagram drawn by Upton. Both of these have been obtained through the kindness of Prof. William Campbell, of Columbia University. All are probably familiar

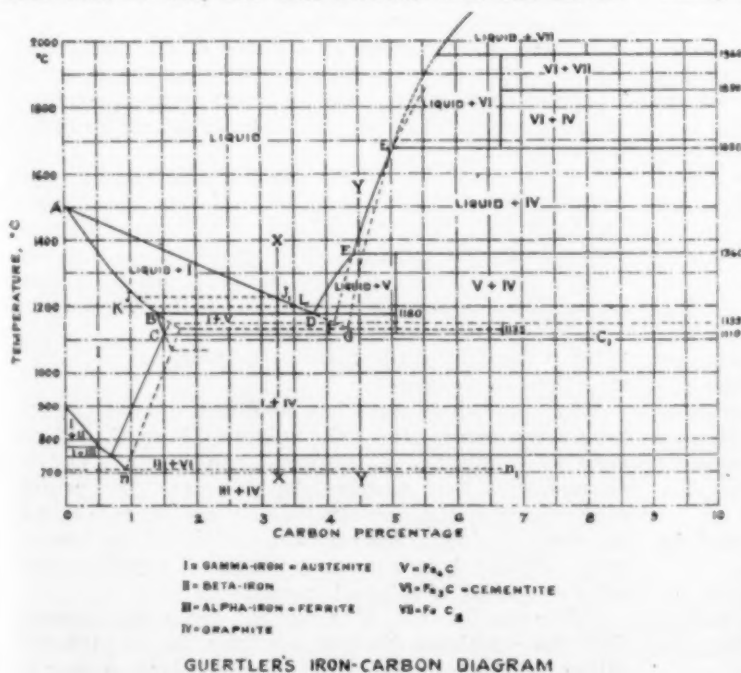


FIG. 1

with the general form of these diagrams. The abscissæ represent percentages of carbon, and the ordinates temperatures. The diagram, within its range, attempts to set forth the changes which occur in any solution of iron and carbon. A horizontal line runs across at the temperature of 1180 deg. C., and two diagonals drawn respectively from the upper right- and left-hand portions meet upon this line at the point corresponding to 4.2 per cent of carbon in Upton's diagram, at 3.8 per cent in Guertler's. The diagrams attempt to show not only equilibrium conditions—that is to say, those conditions which prevail after the mass has been allowed sufficient time in cooling to reach a complete state of equilibrium—but also metastable conditions.

The interpretation of certain of the transformations is extremely difficult. I will not try at this point to make an exposition of the complete diagram, but will only call attention to its salient features. Considering Guertler's diagram and starting with a molten solution above the diagonal line on the left-hand side, we have a homogeneous solution—let us assume one whose composition is represented by the line *XX*. When the temperature falls, the composition remains constant until point *A* is reached, when, if ample time be allowed for the cooling, a solid freezes out, whose composition at any temperature is given by the intersection of the horizontal through that temperature with the line *AB*, in the present instance the line *JJ*, shown on the diagram. The metal represented by the point *J* obviously contains less carbon than that of the whole mass represented by the abscissa of the line *XX*, and the carbon rejected by this solution in freezing must go over into the remainder of the solution, and so increase its carbon. If sufficient time is not allowed in cooling through any range, for instance that from *JJ* to *KL*, the carbon from the solution is not able to diffuse into the solid and bring the percentage up to that represented by the point *K*, but tends more to follow the vertical line from *J* to *K*. This takes less carbon from the solution and leaves the excess in it greater. We have, therefore, the curious condition that the more rapid the cooling the greater the difference in carbon contents of the first and last frozen portions of the original metal.

After the metal has fallen in temperature below the line *BD*, it is entirely solid, but is not yet in its permanent condition, because carbon tends continually to fall out of solution. The method by which this takes place is subject to various conditions, and is not yet fully understood, even among the scientists who deal with this phase of the subject, as will be clearly seen by the difference between the lower portions of Fig. 1 and Fig. 2, which are intended to represent the same set of objective phenomena.

The following brief statement of the possibilities in regard to the transformation of these points is quoted from my reply to the discussion of my paper, "The Effect of Oxygen, etc.," before the Institute of Mining Engineers, published in its *Bulletin*, June, 1914, and was prepared for me by Professor Campbell, through whose kindness I am able to present here three possibilities based on the work of Guertler (who founds his conclusions upon the experiments of Wittorff and Ruff) and one based on Upton's iron-carbon diagram. According to Guertler:

I. In the stable condition above 1360 deg. C. and 4.4 per cent C., we can have liquid + graphite.

At 1360 deg. C. the reaction occurs; liquid + graphite = Fe_3C , and in alloys with 4.4 per cent carbon down to 3.8 per cent we find Fe_3C crystallizing out from the melt.

At 1180 deg. C. we have the eutectic of austenite + Fe_3C .

At 1110 deg. C. Fe_3C breaks up into austenite + graphite.

At 750 deg. C. the eutectoid of ferrite and graphite forms.

These are equilibrium conditions which are reached only with extremely slow cooling.

II. With more rapid cooling, the reaction at 1360 deg. C. does not occur. Graphite separates from the melt, and at 1155 deg. C. we get the eutectic of austenite + graphite.

III. With more rapid cooling, Fe_3C separates out from the melt and at 1135 deg. C. and 4.3 per cent carbon forms a eutectic with austenite; then at 710 deg. C. we have the eutectoid Fe_3C + ferrite, commonly known as pearlite.

According to Upton's diagram, white irons are super-saturated solid solutions which are breaking down; and the stable constituents are austenite + graphite above 1095 deg. C.; austenite + Fe_3C or Fe_3C + graphite below 1095 deg. C.; and at 800 deg. C. Fe_3C appears while Fe_3C disappears. At 600 deg. C. Fe_3C breaks down into Fe_3C . Fe_3C and Fe_3C have yet to be distinguished from Fe_3C under the microscope.

Leaving this for the present, let us consider the conditions represented by an iron-carbon alloy, containing more carbon than that represented by the point *D* on both diagrams. Assume, for instance, iron of a composition represented by the line *YY*. According to both diagrams, when the temperature has fallen to the point where line *YY* cuts the right-hand branch of the curve solidification begins; but in this case it is either Fe_3C , graphite, or Fe_3C which is thrown out of solution.

The relationships expressed by the dotted lines *FE* and *GE*, are too obscure for description at this point, though we may revert to these briefly after examining the action of a few of that infinite variety of alloys answering to the comprehensive name of "cast iron."

In either case, it is well to remember that, when the temperature falls slowly, the iron tends to follow the one or the other of the branches of the curve in cooling. If a hypoeutectic iron—that is, one lying to the left-hand side of the point *D* (for instance, the composition represented by the line *XX*),—selective freezing tends to take place along the line *AB*, with a resulting concentration of carbon in the mother liquor, represented by the distance between the lines *AB* and *AD* on the horizontal line corresponding to the given temperature. But if sufficient time be not allowed then the iron tends to freeze in a purer (that is, lower carbon) condition, with a greater enrichment in this element of the mother liquor.

On the other side of the eutectic point *D* the hyper-eutectic iron tends in freezing to follow along one of the lines *DE*, *FE*, or *GE*, and in any event this corresponds to the falling out of graphite, or a carbide which, being richer in pure carbon, leads to a direct proportional impoverishment of the mother liquor; and this impoverishment in this case is greater if time is allowed for full equilibrium to be reached, and less if this time is shortened.

When the whole mass has solidified, it is at the temperature represented by the points *D*, *F* or *G*, and consists of a mixture of different constituents, and the character of this mixture depends upon the original composition of the iron-carbon alloy and its rate of cooling from its initial temperature to that of the freezing point. This mixture generally contains graphite physically enmeshed, if it be a hypereutectic iron.

Below the line *CC*, it is obvious, from the diagrams, that their authors disagree considerably as to the details of the action, but further graphitization goes on, and the solution of pure iron in cementite becomes poorer and poorer in carbon until the line *nn*, is reached,

when a very important transformation takes place. All the solid solution remaining breaks up into pure cementite in all detached areas and into pearlite, one of the best known constituents of all irons and steels, and one which can perhaps best be described by reference to the fact that 0.9 carbon steel, in its unhardened condition, consists entirely of this material. Pearlite is well known as one of the strongest and toughest of the countless combinations of iron and carbon.

Even at this low temperature, 725 deg. C. or 1337 deg. Fahr., barely a dull red, the iron is not yet in equilibrium. The cementite may break down to pure iron and graphite in relatively large masses. Pure iron or ferrite is only about one-third as strong as pearlite, and, of course, when its continuity is broken up by graphite it is thereby further weakened, and, being in large areas, its effect in weakening the whole structure is very great.

The line *DE* of Upton's diagram may be entirely disregarded, since it is well known that the actual line is much steeper and is probably, nearly if not exactly, as drawn on Guertler's diagram, which is more recent than that of Upton and is based on the researches of Wittorff, the most recent and probably the most accurate of any of the investigations on high-carbon alloys of iron.

Upton's diagram is shown principally for the reason that it contains the vertical line *HK*, since it has been found by actual experience that irons with more than a certain quantity of carbon graphitize to a much greater extent than similar irons containing less carbon, and that high carbon irons not only throw out more graphite than do lower carbon ones, but the combined carbon remaining is very materially less in the high carbon irons than it is in the low. The line *HK* indicates such an action, and is, therefore, to some extent in agreement with the observed facts, although I am quite unable to state whether the exact location of the line at 3.46 per cent carbon is correct.

From the point of view of practical value, two possibilities according to these diagrams stand forth prominently.

1. Graphite can separate directly from the melt. This is contrary to the claims of Professor Howe and Professor Sauveur, but is abundantly supported by the facts. Their contention that this action can take place only through the prior formation of cementite is completely negated by facts of practice which are matters of common knowledge to furnacemen.

2. After solidification, according to Guertler and Upton, in certain areas of the diagram a very slight change in conditions may cause a complete change in the resulting product.

The iron-carbon diagram gives graphically the best information we have concerning the action of alloys of pure iron and carbon, but cast iron is far removed from that theoretical material, as it contains, in addition, silicon, sulphur, phosphorus, manganese, and sometimes oxygen, generally, if not always, in vastly varying quantities. There may be also titanium, vanadium, chromium, nickel and perhaps many other elements present, but the first five are the important ones in commercial pig irons. Each of these exercises its principal action upon the carbon and upon its condition, and as a result we would need in practice a complete diagram of the form given for each. To represent graphically, for instance, the effect of carbon and silicon together, we would require a figure of three dimensions, or, in other words, a solid or "glyptic model." In addition, for each percentage of each of the other elements there would be a variation of this model to express all the facts. The effect of three elements would occasion a model of four dimensions. As matter of

fact, however, we have not as yet sufficient information to make a single iron-carbon diagram with absolute certainty, nor do we know very definitely the quantitative effects produced by given quantities of the other elements I have mentioned. We must needs, therefore, confine ourselves to a consideration of the qualitative effects of the above elements on the iron-carbon solution.

The Shape of the Graphite and the Form of the Crystals

Before dealing with the effects of the other elements, I wish to call attention to two profoundly important facts, no intimation of which can be found in the iron-carbon diagram and the effects of which cannot be recorded upon it. They are, however, of vast industrial and, I think, scientific importance, and are also two factors in the final result to which I shall have occasion to refer frequently. The first is the shape of the graphite particles, and the second the form of crystallization in which the iron solidifies.

The shapes in which graphite can occur vary immensely, and have a corresponding effect upon the structure as a whole. Graphite is, to all intents and purposes, a foreign substance in iron. In other words, we could make a steel of the same composition as a good cast iron, counting only the combined carbon, and could by suitable heat treatment bring the combined carbon into the same condition as in cast iron, and have a homogeneous material of the same nature but free from these particles of a virtually foreign substance; this would constitute an impure steel.

The smoothness and lubricating qualities of graphite are well known, as is also the fact that it is entirely without physical strength. To intersperse flakes of this material thickly through cast iron can have obviously no other effect than to break its continuity and destroy the bonds with one another of the particles of iron proper. Good gray iron contains about 3.0 per cent of graphite, and the specific gravity of this is about a fourth that of iron. This corresponds to about 12 per cent by volume.

One of the things which we have discovered is that graphite in some iron is of extreme thinness and of vast extent, while in other iron it exists in scarcely more than little round knots or balls. Consider this enormous percentage by volume and the extreme thinness of the plates of graphite, which, judging from the photomicrographs, are probably less than 1/1000 of an inch thick, and you will see what an enormous area they must have to make up 12 per cent of the volume, and what a vast amount of damage they must do to the structure of the iron.

If we were to make up concrete and add to it 12 per cent by volume of, say, tin scrap in small, irregular pieces, about 1 in. across, and well greased to prevent the concrete from adhering to them, and were to stir these thoroughly through the mass, and then pour the mixture into a form, do you think that the resulting concrete would be particularly valuable? If, now, instead of tin scrap an inch across, we used iron balls of about the same specific gravity and to the same extent by weight, and stirred those thoroughly through the mass, can you doubt which concrete would be the better?

As to the form of crystallization, the eutectic of 4.20 carbon crystallizes from a pure iron-carbon solution in a series of flat plates, the cross-section of which is similar to that of a number of fern leaves laid side by side, as shown by photomicrographs, Figs. 3 and 4. In certain kinds of iron these plates grow so large as to be plainly visible to the naked eye. When they remain

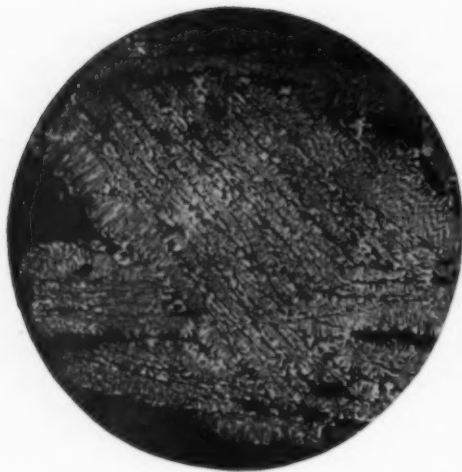


FIG. 3—ETCHED (MAGNIFIED 38 DIAMETERS) SPOT OF SPOTTED IRON



FIG. 4—ETCHED (MAGNIFIED 100 DIAMETERS) SPOT OF SPOTTED IRON

white, they are as smooth as if polished, and shine brilliantly when their surfaces are exposed. If you imagine a series of blocks of mica thrown loosely into a mold, and a cement or glue poured in to fill up the spaces between, and the resulting structure subjected to stress, you would not expect to find it very resisting, no matter how good the cement, because the blocks would cleave apart on the smooth faces of the mica. It is the same with iron which has this crystallization. No matter how good its chemical composition may be, even if the combined carbon be of the exact amount to give the greatest strength, the iron will be weak and worthless.

If, on the other hand, even the concentration which comes from progressive freezing results in the formation of little or no eutectic, the solution freezes into a network structure, which I have supposed is the same as that in the steel named by Professor Howe "Primaustenoid." The best illustration of this structure I have is that shown by Figs. 5 and 6. I think you will see that the structure as a whole is vastly more homogeneous than the eutectic and quite lacking in the lines of cleavage which give the latter its bad qualities, but that such lines of crystallization as do appear are in the form of a meshwork, so that the whole structure, where not absolutely homogeneous, is interlaced together.

These are the two facts which render the amount of graphite, and even the percentage of combined carbon, matters of secondary importance, and which minimize the value of Professor Howe's brilliant generalization on that subject.

The qualities by which different irons are distinguished from one another are very many. I have classified them as follows: strength, flexibility, elasticity, density or closeness of grain, fluidity, freedom from shrinkage, and machinability. These represent qualities generally desirable, but the importance of some is the greatest in one class of work and of others in other classes of work; in fact, advantages for one class of work may be positive disadvantages for another. These are matters which depend upon the purposes for which the castings are to be used, and need not be discussed in detail here.

Let us return now to the elements of prime importance—carbon, silicon, sulphur, phosphorus, oxygen, and manganese—and con-

sider the effects which varying quantities of each of these may have upon each of the above qualities of major importance. You will see that we have here a practically unlimited number of combinations, and that it is virtually impossible to do anything more than to discuss the general results of the variations of the elements within the range of practice in different lines of foundry work.

Carbon

The subject of the effect of variations of carbon on cast iron has been neglected far too much. The carbon

determination in cast iron is a difficult one, and unless made by a man with considerable experience along this line is of no value. Errors to the extent of 1 per cent of the weight of the iron (not the carbon) have frequently been made by good and conscientious chemists through the difficulty of manipulation and, until recently, through the absence of suitable apparatus for the purpose. At the Ashland plant of the Lake Superior Iron and Chemical Company, where the researches whose results I am about to give you were begun, we introduced a long silica tube heated by an electric resistance coil, with a pyrometer to control the temperature, and burned the carbon in a stream of purified oxygen, catching the carbon dioxide in barium hydrate solution and determining its amount by titration—practically the same method as used for carbon in steel. We became so convinced of the importance of carbon determinations that we put an extra man into the laboratory in order to obtain one on every cast. Even with this excellent apparatus it took months to learn necessary temperature control and other precautions which must be taken to secure correct results. The difficulties are greatly increased by the fact that one iron will be heated to incipient fusion and sintered by a given

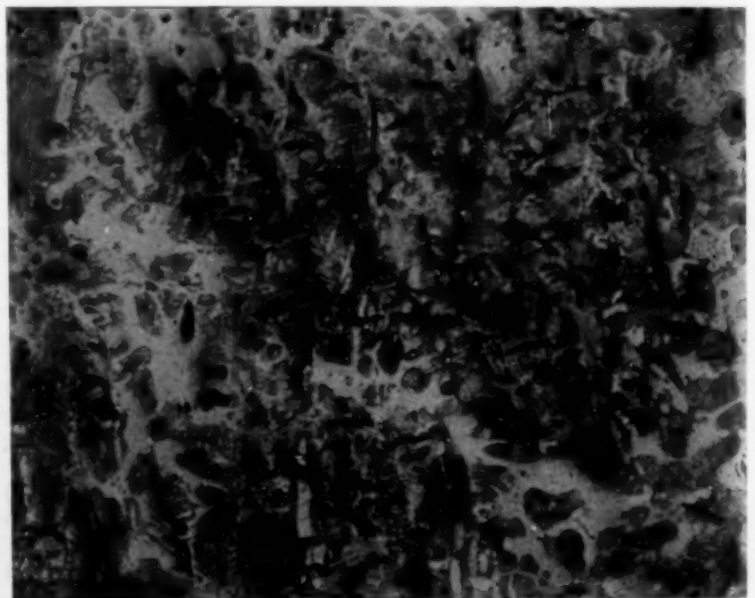


FIG. 5—ETCHED (MAGNIFIED 100 DIAMETERS) GOOD CHARCOAL IRON, SHOWING MESHWORK STRUCTURE

temperature, thus sealing up some of the carbon and giving a low result, while another iron at the same temperature may not be hot enough to give off all its carbon and may show a low result on that account. I believe these difficulties of making carbon determinations at all, and of securing dependable results when they are made, have militated more against the progress of cast-iron metallurgy than any other factor.

The results of variations in carbon and their effect on the form of crystallization were set forth at some length in a paper by myself, read before the American Institute of Mining Engineers and published in 1912, entitled "Effect of High Carbon on the Quality of Charcoal Iron."

The results we obtained have been briefly mentioned above, and were that iron of the eutectic ratio crystallizes in smooth, flat plates without cohesion between either the plates in one group or between those of one group with those of another. If the iron is above the eutectic ratio—that is, of a composition represented by the right-hand branch of the iron carbon diagram—the excess carbon above the eutectic ratio falls out in the form of graphite as the iron cools along one of the lines *DE*, *FE*, or *GE*, and in that event, of course, the whole mass, except the ejected graphite, is at the eutectic ratio at the point of solidification and freezes as a mass of eutectic, perhaps interspersed with the particles of hypereutectic graphite. During cooling after solidification, if the silicon be high enough it forces the decomposition of the eutectic plates into ferrite, pearlite, and graphite. These are formed in the solid condition and necessarily have the orientation of the plates of eutectic from which they are born, and, in consequence, high carbon irons, when they have sufficient silicon to make them gray, have an appearance of high cleavage, especially around the corners of the pigs and at other points where they are quickly cooled. These cleavage planes are black or gray, but are of the same general character as the brilliant white plates, which occur in the same iron when it is white or mottled. They are the result of the breaking down or graphitization of the original eutectic plates (Figs. 7 and 8).

These irons have been noted for a curious peculiar-



FIG. 7—UNETCHED (MAGNIFIED 70 DIAMETERS) HIGH-CLEAVAGE IRON, SHOWING ROWS OF GRAPHITE FLAKES ORIENTED AFTER EUTECTIC PLATES FROM WHICH THEY WERE FOCUSED

ity; ordinarily we expect to see the part of the iron cooled white first and the part last cooled gray, if there be any white or any gray at all, which means that the white is outside and the gray is in the center. But in these irons the outside of the pig is gray, while there is a white chilled spot in the center, or just above the center, of the pig (Fig. 9). This curious phenomenon has caused much racking of wits, especially during the course of our investigation at Ashland.

Finally, it occurred to me that this spot occupied the position which a segregate would take. An analysis of the spot and other portions of the pig showed that there was indeed a segregation. In irons of moderate carbon, the portions first frozen are well below the eutectic ratio, but the portions last to freeze have the carbon concentrated in them by the selective action of freezing and therefore crystallize in the eutectic form. It is well known that the evolution of graphite is accompanied by a considerable increase in volume, and, if this be resisted with sufficient pressure, graphitization cannot take place, and the iron must remain white. I have seen a white spot produced in the center of a pig

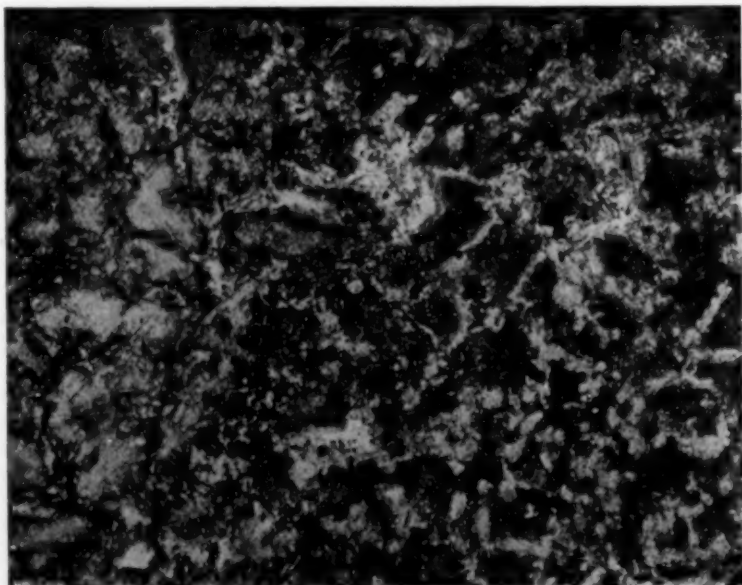


FIG. 6—ETCHED (MAGNIFIED 100 DIAMETERS) COKE IRON WITH OXYGEN ADDED. FIRST HEAT OF JOHNSON IRON EVER MADE. (PHOTOGRAPH DUE TO KINDNESS OF PROF. WILLIAM CAMPBELL)



FIG. 8—ETCHED (MAGNIFIED 70 DIAMETERS) SAME AS FIG. 7

of good iron by cooling the exterior very rapidly. This took away the heat from the outside, while the center still remained hot enough to retain its carbon in the combined condition. The resulting contraction of the outer metal prevented the graphitization of the center, which would have taken place as the temperature fell, by preventing the necessary increase in volume.

It has previously been suggested by Mr. H. E. Field that this spot was caused by the pressure resulting from the contraction of the outer shell of first frozen metal upon it, but, as all pig iron solidifies under these conditions and only a small portion of it contains this spot, this solution was obviously inadequate.

The reason for the automatic formation of the white spot in these spotted irons is probably to be found in two factors:

First.—The segregate at the center is the eutectic, and therefore has a freezing-point very decidedly lower than the outside, so that the shell is thoroughly solidified and able to exert a considerable pressure when the center is still molten.

Second.—These spotted irons occur only within a limited range of silicon, from 0.8 per cent down to 0.3 or 0.4. The former limit of silicon is sufficient to force graphitization, even against the resistance of the external shell. Below the latter limit the iron is practically all white, although in the case of a high carbon iron it may be heavily specked with primary graphite scattered between the blocks of eutectic plates which constitute the body of the structure.

In regard to spotted iron, it is a matter of observation that an iron may show a "spot" if quickly cooled, but will not do so if cooled slowly. For instance, the 1½-in. test bars made at every cast at Ashland would sometimes show a spot when the pigs did not. This is evidently because of the fact brought out in the explanation of the iron-carbon diagram that the quicker the cooling and the less time allowed for the diffusion of the carbon into solidified portion of the metal, the greater the carbon concentration in the last frozen portion. Iron which, when slowly cooled, is far enough below the eutectic ratio not to undergo sufficient carbon concentration to show a "spot," undergoes, when quickly cooled, a greater carbon concentration, because there is not enough time allowed for the diffusion of the carbon throughout the mass, and so shows a spot.

These high carbon irons were noted among practical men for very deficient chilling power, a fact amply confirmed by observation of the "chill pig" at Ashland, of which one was cast in every bed, these irons having only a fraction of the chill which they should have for a given silicon. This action, may, I believe, best be explained by reference to the well-known law of physics, that a solution of, say, common salt may be cooled below the point at which it can theoretically retain the amount of salt which was dissolved at a higher temperature, and may, if kept quiet, retain the excess to a temperature considerably lower than that of equilibrium; but if a single crystal of salt be dropped into the solution, the excess will instantly crystallize out around it, and the solution will at once drop to the equilibrium ratio. So in iron, if it be cooled more rapidly than will permit it to reach equilibrium, under ordinary conditions more carbon will be retained in combination than the equilibrium ratio would call for, but when the mass is filled with graphite flakes deposited from the molten condition (which, as I have explained, takes place with these irons) these graphite flakes act as centers of precipitation and cause more carbon to fall out of the solution than would do so if there were less total carbon present. Thus, by the aid of the microscope and with a little help from the iron-carbon diagram, we find the



FIG. 9—TYPICAL FRACTURE OF "SPOTTED IRON"

explanation for the characteristics of these irons easily translatable into terms of analysis, namely, their high carbon content, and so solve this long-standing riddle.

In this connection, it must be pointed out that, while 4.2 per cent is the eutectic ratio for a pure iron-carbon alloy, the eutectic point is lowered by the addition of silicon, and probably reaches to 3.8 per cent or even lower when the silicon reaches about 2 per cent or more. On the other hand, other things being equal, the total carbon falls as the silicon rises beyond, say, 0.5 per cent, because carbon and silicon exert to some extent a mutually exclusive action upon each other, exactly as water saturated with calcium chloride will not take up as much common salt at a given temperature as will pure water. So, as the silicon in iron rises, the carbon falls until we reach "silvery iron"—which is a much lighter gray than ordinary iron because of the small quantity of carbon present, in spite of its being entirely graphite, the carbon with 4 per cent silicon probably falling to below 3 per cent, as against nearly 4 per cent in coke iron, and sometimes almost 5 per cent in spotted charcoal iron of about 0.5 per cent silicon.

On the other hand, the carbon falls from this point (about 0.5 per cent silicon) as the silicon falls, because these irons are made in a colder hearth. The temperature of the iron as produced is not sufficient to enable it to take up its maximum carbon. The fact that at this silicon percentage occurs the maximum carbon is probably also a factor in the occurrence of spotted irons within a limited range on either side of this point.

While it has been demonstrated that high carbon leads to certain exceedingly objectionable qualities in iron, it is, nevertheless, not to be assumed that high carbon is always bad, or that the lower the carbon the better the iron, since this is far from true. The hardness of chilled iron depends largely upon its content of iron carbide. This compound contains 6.66 per cent of carbon, so that an iron with even 4 per cent of carbon is less than two-thirds carbide or cementite. The farther we fall below 4 per cent, the smaller the percentage of carbide which can be formed from the carbon present, and, other things being equal, the softer the chill

in the same proportion. In order to obtain the benefit of the high carbon, we must be able to retain the carbon in the combined condition and not have it thrown out as graphite either before or after freezing; this, you will see later, we now have a means of doing. For chilling purposes, therefore, the carbon in iron needs to be high. When the carbon falls much below 3 per cent the character of the metal seems to change. It is probably for this reason that steel scrap, with a mixture of which by good practice castings can admittedly be made strong, can only be used in a limited proportion in chilled castings, because, if used to a greater extent, it dilutes the carbon of the whole charge so much as to impair the hardness of the chilled material.

So far as the blast furnace is concerned, we do not need to concern ourselves with carbon lower than about 3.5 in any ordinary range of silicon, since as far as my knowledge goes, furnaces seldom make lower carbons than this under normal working conditions, although a furnace too cold to function properly has often been known to produce what is virtually wrought iron, which, of course, has too high a melting-point to run from the furnace and which causes endless trouble in consequence.

The lowest carbon I have ever seen was 3.03 per cent. This was a charcoal iron produced when the furnace was in trouble. Such an iron contains much oxygen-bearing material, which reacts with the carbon and causes the metal to be filled with a great mass of blow-holes, so that each pig swells up to the section and general appearance of a well-made loaf of bread, and makes the material worthless for commercial purposes. This is known as "Spongy. No. 6."

The melting point of the iron-carbon alloys, as may be seen from the diagrams, Figs. 1 and 2, falls from 1500 deg. C. for pure iron to 1180 deg. C. at the eutectic point. The lowering of the melting point taking place along a straight line and being, therefore, proportional to the increase in carbon, consequently if the carbon be lowered to too great an extent, the melting point becomes so much raised as to make the metal difficult to handle in the cupola, and this rise in temperature exerts a certain very detrimental influence on high-class iron, which will be shown later.

For strength alone there seems to be no doubt that a reduction in the carbon is good, even below 3 per cent, but it is probable that only material ranging from 3 per cent to 5 per cent in carbon should be considered cast iron. The vast majority of all the iron produced lies within the comparatively narrow limits of 3.5 to 4.25 per cent.

The other elements exert an influence on the amount of carbon which iron can contain, and also on the eutectic ratio, but these influences will be better discussed, in so far as they are known, in connection with the elements concerned.

(To be continued)

Asbestos in Arizona.—Up to the present time Canada was the only locality in America where long fibered asbestos was obtained. While Wyoming produces asbestos, this material is of the serpentine type and is short fibered. Lately large deposits of the long fibered type of asbestos were discovered in Arizona, the largest deposits being in the Sierra Ancha and at Ash Creek. The asbestos of Arizona is chrysotile asbestos and is found in lime and diabase. Its nature makes it especially useful for the manufacture of fabrics. The high-grade material is at least 50 per cent of the total material mined and is the only material that is being shipped due to the high freight.

Recent Chemical and Metallurgical Patents

Iron and Steel

Blast Furnace Top.—The masonry shaft of a blast furnace is subject to considerable longitudinal movement under expansion and contraction. In order that these shall not be transmitted to the masonry lining of the top, and thus distort it, an independent top has been devised and patented by WILLIAM H. BAILEY of Gary, Ind. A diagram of this top is shown in Fig. 1.

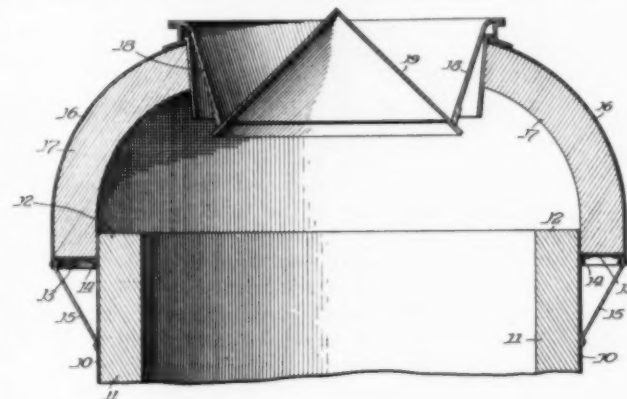


FIG. 1—BLAST FURNACE TOP

The shell for the blast furnace shaft is shown at 10, with the lining represented by 11. This shell and lining terminates at 12. An annular plate 13 is secured to the shell 10 by means of an angle 14 and braces 15. The shell or covering 16 for the top is secured to the outer edge of the shelf 13, and is lined with masonry 17. This arrangement permits of an increase in the size of the top, and while the top is not connected to the blast furnace shaft, it is rigidly secured to the shell, without danger of being blown off, if a slip occurs. Other advantages claimed for this design are that it permits of the use of a masonry lining for the top without lessening the space within which distribution may be made, and provides ample space for the location of downcomers in the top if desired. (1,193,750, Aug. 8, 1916.)

Sintering.—A new method for sintering fines has been patented by MAX McMURRAY, BENJAMIN J. MULLEN and HARRY PEPPEL of Cleveland and Leetonia, Ohio. It consists in first forming a porous hearth on the bed of a sintering pan, about $\frac{1}{2}$ in. in depth. The material generally used is lime-stone screenings. On top of this is placed the moist or dry fines, mixed with coke-dust if necessary. The charge is then ignited similarly as in the Dwight-Lloyd sintering process and the combustion maintained by sucking air through the charge. The new feature consists in adding water to the charge continually or intermittently, as circumstances may demand, after sintering heat has been attained. The water thus added forms steam, which passes through the charge with the air. The patentees claim the following economical advantages over the common practice: it reduces the time required from 25 to 50 per cent; the product is more uniform; the exhaust apparatus may be run at a lower vacuum and finally the grate-bars have a longer life. (1,183,891, May 23, 1916.)

Sintering.—A patent has been granted to FRANK D. CARNEY and RICHARD V. MCKAY of Steelton, Pa., relating to a cover for sintering pans, the main features being its horizontal mobility on wheeled axles and its raising and lowering mechanism. The latter consists in a set of pivotally connected levers on the cover itself,

connected to the axles, permitting the raising and the lowering of the cover from a single operating position. (1,190,513, July 11, 1916.)

Gold and Silver

Method of Extracting Gold.—A process for the extraction of gold and silver especially from refractory ores, preventing formation of detrimental cyanide compounds and the conversion of the cyanide solution in part to cyanate has been patented by ALBERT W. SMITH of Cleveland, Ohio. The process consists in grinding the ore dry to about $\frac{1}{2}$ -in.; it is then further reduced by grinding in an alkaline solution of potassium cyanide and potassium bromate, using approximately 1 lb. of the former and $\frac{1}{2}$ lb. of the latter per ton of ore. After reducing to 10 mesh, the material is treated in a tube mill. The tube mill product passes to a classifier, where the 200 mesh product is floated off and the sand and coarser material returning to the tube mill. The solution containing the slimes passes to a thickener, the slimes are separated and the solution is reused in the process. The pulp from the thickener goes to agitators, where it is aerated and more cyanide, bromate and lime added if necessary. The aeration lasts from 6 to 72 hours. The pulp is then filtered and washed, the solution going to the precipitation department and the washed pulp being discarded. (1,193,197, Aug. 1, 1916.)

Electrochemical Treatment of Refractory Ores.—A patent was granted to WILLIAM HOLMAN JAMES of Johannesburg, South Africa, for the treatment of refractory ores of gold and silver prior to the cyaniding process. Essentially the process consists in electrolyzing a solution of a salt of a mineral acid, withdrawing separately from the electric circuit the portion of the solution in the vicinity of one of the electrodes, treating the ore therewith until the refractory constituents are dissolved and removing the solution containing the refractory elements. The ore then is left amenable to the ordinary cyanide process for the extraction of the values. (1,184,456, May 23.)

Copper, Lead and Zinc

Electrolytic Cell.—An apparatus for electrolyzing copper solutions has been patented by WILLIAM E. GREENAWALT of Denver, Col. The main objects in view were the more efficient application of the electric current, the retarding of the disintegration of the electrodes, keeping the electrodes free from polarizing agents and maintaining the apparatus in continuous operation for extended periods. The main features employed are: the separating of the anolyte and catholyte by means of a diaphragm, thorough agitation of the electrolyte and the addition of depolarizers and the automatic removal of anode slimes. The cell is of the horizontal type. The main chamber contains a horizontal cathode and the catholyte. Into this is placed the independent porous anode bell, so constructed, that it may be differentially oscillated by some mechanical device. The anode compartment is an independent unit and may be bodily removed from the cell. The oscillating motion serves to automatically agitate the electrolyte, to clean the anodes and to collect the anode slimes at one end of the anode chamber, permitting the easy removal of said slimes. The diaphragm also diminishes the fouling of the cathode electrolyte. The depolarizer added is usually sulphur dioxide. The automatic handling of the anode slimes and the foul electrolyte makes it possible to increase the period of operation. The following new facts have been demonstrated by the use of this new cell: First, the amount of lead perox-

idized at the anode, on using lead anodes was reduced from 1600 lb. of lead to 40 lb. per ton of copper and secondly abnormally high current densities could be employed, i.e. 104 amperes per square foot gave an efficiency of 99 per cent. (1,187,903, June 20, 1916.)

Disintegration of Anodes.—A process for preventing the disintegration of graphite electrodes in the electrolysis of solutions was granted to GEORGE D. VAN ARSDALE of New York, N. Y. It consists in adding enough depolarizing agent or agents to prevent the formation of gaseous constituents in the free state. The gases originally formed unite in the nascent state with the depolarizer under the given conditions. (1,193,741, Aug. 8, 1916.)

Zinc Condensation.—A patent was granted to HENRY SWIFT KIMBALL of St. Louis, Mo., for increasing the efficiency of zinc condensation. The essential feature is the attachment of a Cottrell collecting device in the zinc condenser. The high electrical potential precipitates the finely divided zinc in the condenser gas, thus collecting it in the metallic zinc in the condenser and reducing the amount of blue powder formed in general practice to a great extent. (1,189,830, July 4, 1916.)

Zinc Recovery.—CHARLES H. FULTON of Cleveland, Ohio, has patented a method for making briquettes, which may be used in zinc retorts for the production of zinc. The ore is crushed and calcined in the usual way and then mixed with pulverized coke and a binder such as pitch or a mixture of pitch and tar. The thoroughly mixed mass is then heated to the melting point of pitch and passed through the briquette press, where it is subjected to a pressure of 500 to 1000 lb. per square inch. The briquettes are then heated until the binding material has been coked. The heating should be done under non-oxidizing conditions. The novel feature of these briquettes is their structure, consisting essentially of a large number of ore particles embedded in a matrix of coke. The briquettes are retorted and will maintain their volume and form during the operation. (1,193,680, Aug. 8, 1916.)

Process for Manufacturing Lead Sulphate.—A method for producing neutral and basic lead sulphate in a fine state of division was patented by BERNARD S. WHITE of Joplin, Mo. Litharge is converted into a fume by blowing hot air over it while in the melted state. The fume thus formed is then mixed with sulphur dioxide gas and an excess of air. The whole is then heated to such a temperature as to insure the formation of the desired lead sulphate. (1,187,949, June 20, 1916.)

Welding

Welding Unlike Metals.—An interesting process of welding unlike metals, which is stated to be particularly applicable to uniting iron or steel with copper or copper alloys, is patented by FRED. B. COREY of Barberton, Ohio. The process is somewhat similar to soldering, except that the metals when joined cannot be separated by heating the joint above the melting point of the metal used in welding.

In joining an iron or steel bar to a hollow copper tube by this process so that the copper tube surrounds the bar, the iron or steel bar is first thoroughly cleaned and the surface then covered with an alloy of tin and lead. This coating may be applied by dipping in a bath of metal or by means of a soldering iron or by any of the well-known soldering or tinning processes, using as a flux a solution of zinc chloride or any of the commercial "soldering" acids or fluxes.

While the low-melting-point metal is still hot, the superfluous metal is wiped off, and the iron bar allowed to cool. The copper tube is then heated in a bath of potassium chloride to prevent oxidation, and the bar pressed into the tube. (The inside diameter of the tube when cold is a little less than that of the bar.) The bar and tube are then heated until the lead-tin mixture alloys with the copper, forming a tight joint. The temperature used should be as high as possible without melting the copper metal. In welding copper to steel, good results were obtained with a temperature of 900 deg. C. (1,193,667, Aug. 8, 1916.)

Nitric Acid

Oxidation of Ammonia to Nitric Acid.—Interesting developments in the production of nitric acid by the oxidation of ammonia are contained in three patents recently issued to WALTER S. LANDIS of New York City (assigned to Frank S. Washburn of Nashville, Tenn.). In passing an ammonia mixture over a catalyser to form oxides of nitrogen, the combustion takes place best at about 700 deg. C. With a mixture of 1 volume of ammonia to 15 volumes of air the resulting flame temperature is only about 460 deg. C. Thus there is a deficiency of 2670 calories per cubic meter of ammonia burned. With 1 volume of ammonia to 10 volumes of air the flame temperature is only 640 deg. C. With a 1 to 7½ mixture the right temperature would be produced, but when less than 1 to 10 is used it does not operate well. Therefore a certain amount of heat must be applied to the reaction. The present patents propose to supply this heat by passing a current through the catalyser. A special form of catalyser, as described in one patent, is used, constructed as shown in Fig. 2. A perforated receptacle 1 of re-

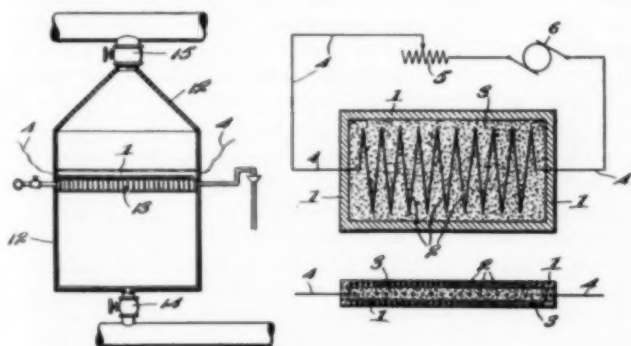


FIG. 2—PLATINUM CATALYSER

fractory material contains a resistance 2 of iridium-free platinum wire. Surrounding this resistance is a powdered catalyzing material 3, which may consist of platinized asbestos, or other non-conducting salts as plumbates, manganates, etc. In the other patent the catalyser consists of fine platinum wire wound around a frame of insulating material. This catalyser is arranged in the oxidation chamber 12, as shown. A feature of the process is the cooling of the mixture before passing it through the catalyser. Refrigerating coils may be used in addition to the cooling arrangement 13, shown. (1,193,798-799-800, Aug. 8, 1916.)

Coke Ovens

Recuperator Wall for Coke Ovens.—In order to effect greater heat economy in coke oven operation a form of recuperating wall has been patented by ARTHUR ROBERTS of Evanston, Ill. This wall is made up of blocks laid in courses, the blocks of each course breaking joints with the blocks of the adjacent courses.

Each block has a recess in the center of its side face and in its bottom face to provide a meshwork of interconnected passages on the interior of the wall. This wall is placed between the walls of two carbonizing chambers, and becomes heated by contact with the walls of the carbonizing chambers. The air to be used in burning the gases, which are passed through the walls of the carbonizing chamber, is preheated by passing it through the recuperator wall. (1,193,069, Aug. 1, 1916.)

Sodium Hypochlorite

Electrolytic Cell for Production of Bleach.—An electrolytic cell for the production of sodium-hypochlorite in which the electrodes are built up in removable units is patented by ALBERT HOLLIDAY of Wimbledon, London, England. Two cross-sectional views of an electrode unit are shown in Figs. 3 and 4 respec-

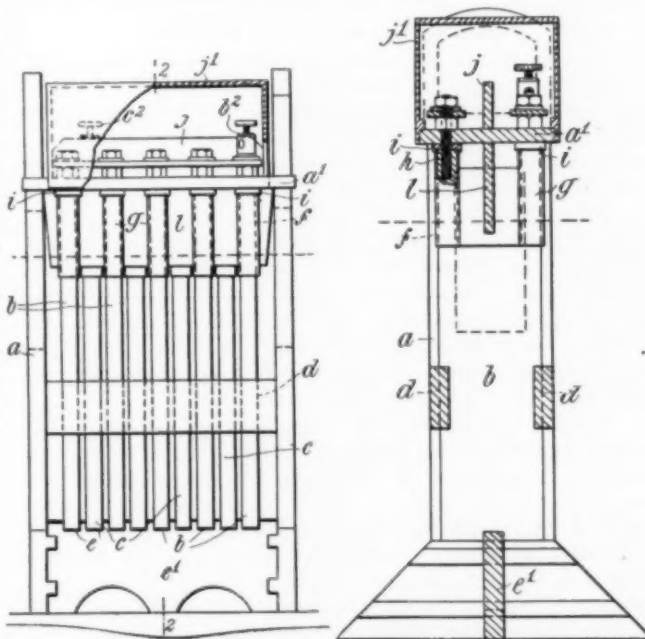


FIG. 3—SIDE ELEVATION OF ELECTRODE UNIT

FIG. 4—END ELEVATION OF ELECTRODE UNIT

tively. Fig. 3 is a side elevation and Fig. 4 is an end elevation. The unit consists of a removable frame *a* of acidproof, non-conducting material. One set of electrodes is represented at *b* and another set at *c* (Fig. 3). These are arranged close together, that is, about ½ in. apart, and a heavy current density is used. The electrodes are connected in sets by lugs *f* and metal studs *h* to common busbars, each with a common terminal *b*² and *c*². Each set of electrodes may be used either as anodes or cathodes. This feature is of advantage when the cathodes become coated, as by reversing the current the deposit may be dislodged. The connecting lugs *f* are coated with acidproof solution and enclosed in a sheath *g* of acidproof non-conducting material. A rubber washer *i* is used between the upper ends of the lugs and the top plate *a*¹ of the frame to insure a liquid tight joint. An insulating partition *j* is provided between the two busbars, and over this and the busbars and terminals is fitted a cover *j*¹ adopted to prevent any corrosion of these parts from the chlorine. It is claimed that absorption of chlorine by the caustic soda solution formed is facilitated owing to the distance of the upper edge of the electrodes below the surface level of the liquor and by the sheathing of the lugs. (1,193,786, Aug. 8, 1916.)

Synopsis of Recent Chemical and Metallurgical Literature

Colloidal Chemistry

Selective Adsorption and Differential Diffusion.—An interesting contribution to the symposium on "colloids," held at the New York meeting of the American Chemical Society, was presented by JEROME ALEXANDER. He states that substances in solution diffuse at different rates through finely divided or colloidal structures, and may thus be more or less completely separated from each other by differential diffusion. This effect is accentuated when one or more of the substances is selectively adsorbed by the structure through which the diffusion takes place. These facts are illustrated by tubes showing the separation, into its components, of ferric chlorid upon diffusion through a sensitized agar gel, and also by the separation of mixtures of dyes upon diffusion through blotting paper.

"The action of selective adsorption and differential diffusion in effecting secretion and excretion must be at once manifest. Easily hydrolyzable compounds may be thus split up in the body, and yield secretions of acid nature like the gastric juice, or of alkaline nature like the pancreatic juice, depending upon the structure of the organ, the location of its cavity and of its afferent and efferent vessels. Individual compounds in the blood stream or other body juices may also be selectively diffused out, concentrated, or separated from other accompanying substances. By selective adsorption, circulating substances may be fixed and taken from the circulation; in fact, poisons are usually taken up selectively by certain organs or tissues. . . ."

"In plants, differential diffusion and selective adsorption seem to be intimately bound up with growth and the circulation of the sap. The plant tissues are mainly colloidal gels or finely integrated structures, and as the sap circulates or diffuses through them, each tissue selectively adsorbs and elaborates certain particular constituents. Thus, with the potato and tapioca plant, the starch-forming substances are fixed in the roots; with the sago palm they are fixed in the stem pith, and with cereal grains, in the seeds. As long as the adsorptive tissues are unsaturated or are multiplied, so long can growth continue. . . ."

"Adsorption and diffusion are phenomena that lie in the colloidal zone, which imperceptibly blends into the physical on one hand and into the chemical on the other. The dimensions involved approximate the so-called radius of molecular attraction so that the forces of surface tension, capillarity, electric charge, colloidal protection and the like are all influenced by chemical forces. Indeed, before substances can unite chemically, their particles must be brought first into proper subdivision and proximity by solution, fusion, ionization, or even by mere pressure, as has been demonstrated by W. Spring, who caused fine dry powders to combine by high pressure.

"If the degree of subdivision is not profound enough to permit of the combination of isolated atoms or ions with each other, chemical combination in the strict sense may not occur, but there may be produced "adsorption compounds" resulting from the union of atomic or ionic mobs in indefinite or non-stoichiometric proportions, under the influence of more or less modified chemical forces.

"On the other hand, if the degree of subdivision proceeds far enough, real chemical reactions may occur and be rendered irreversible by the diffusion or adsorption of one or more of the products into a surrounding colloidal sol or gel. When we consider the

great variety of bio-colloids and their susceptibility to changes of structure and diffusive or adsorptive capacity, we can easily understand the almost infinite number of reactions that may go on within their recesses, as they swing the balance of the law of mass action over particles reduced to a reactive degree of subdivision. And we must not be surprised to see technical processes develop upon the basis of these principles."

Emulsions and Suspensions With Molten Metals.—At the New York meeting of the American Chemical Society, a paper was presented on this subject by H. W. GILLET, of which the following is a short abstract:

The difficulty of getting aluminium chips and "blue powder" to coalesce in melting is due to the envelopment of the globules by a skin or oxide or other impurities, and to get coalescence the disperse phase of the "emulsion" must be reversed. Enclosures of slag, dross or gas bubbles in castings may be looked upon as due to an emulsion or suspension in the molten metal. While such emulsions are generally undesirable, uniform emulsions in metals may possibly have valuable properties. Hence the colloid chemist should extend his field of work and show the metallurgist and foundry man how to break up, how to make and preserve such emulsion.

Paints.—In discussing paints at the colloid symposium of the American Chemical Society, T. R. BRIGGS said the properties of pigments are influenced fundamentally by the degree of subdivision of the particles. For the special case of a mixture of two pigments of different colors, the tinting power of one pigment in the mixture is dependent chiefly upon the relative size of the particles. If one pigment is relatively fine and the other coarse, and if the finer particles coat over the surface of the coarser ones, the color of the mixture is the color of the finely ground pigment. The theory leads to an understanding of the use of inert pigments as diluents.

Vulcanization of Rubber.—The various theories expounded to account for the phenomena of rubber vulcanization were discussed in a paper presented by D. SPENCE at the New York meeting of the American Chemical Society. The paper was presented at the colloid symposium. The author outlined four different theories which include all the attempted explanations of vulcanization. These are: 1, Chemical reaction; 2, Adsorption; 3, Polymerization; 4, Rubber and rubber derivatives. The theory of an actual chemical reaction taking place between the sulphur and the rubber was long held by many to be the explanation of vulcanization. Experimental data are, however, more in accord with adsorption than with a chemical reaction theory. The polymerization theory that the sulphur causes an increase in the number of atoms in the rubber molecule is giving way to a later and more plausible theory proposed by a Russian chemist, viz., that a rubber derivative is formed when sulphur is added to rubber, and this rubber derivative is adsorbed by the balance of the rubber. He has made extensive experiments and the theory so far seems to hold. According to this theory vulcanization is a compromise between chemical reaction and adsorption.

Plaster of Paris.—A paper on this subject of which L. A. KEANE was the author was presented at the New York meeting of the American Chemical Society. The paper was read by Dr. W. D. Bancroft. He said that in making investigations on plaster of Paris he found that, according to the literature, they heated gypsum to 200 deg., or a little higher in this country to make plaster of Paris, whereas in Germany they heated

to a much lower temperature, approximately 130 deg. The reason for this was not evident until investigations showed that the time factor affected the end product, and whereas in Germany they heated to a relatively lower temperature for a longer time, in this country they heated to a higher temperature for a shorter time, giving approximately the same amount of dehydration of the gypsum. The question of wetting was then investigated to determine why some plasters would set and others would not. The investigations showed that it was simply a question of fine grinding and that dead-burned gypsum, which ordinarily will not set, will set if ground fine enough. The setting property depends on relative size and not on different chemical modifications of the material.

Potash

The Potash Situation.—In an American Chemical Society paper presented at the New York meeting, H. A. HUSTON said that no potash had been received from Germany this year, though some has been received from other countries. A few minor waste materials, which have always been sources of potash, such as tobacco stems, wood ashes, etc., have been better utilized than heretofore. About 45 tons of K_2O per day are being produced from new sources, which is about 6 per cent of our normal requirements. Of the sources yielding this, viz., kelp, cement, alunite and Nebraska Lake, the last was responsible for more than half the total output. He said the potash mines in Germany were not full of water as reported, but were operating regularly at nearly normal capacity.

Viscosity

Measuring Viscosity of Very Viscous Substances, such as Heavy Oils, Petroleums, Asphalts, Resins, etc.—Bureau of Mines Technical Paper 157, "A Method for Measuring the Viscosity of Blast-Furnace Slags at High Temperatures," contains a description of the new Feild high-temperature viscosimeter by which the viscosity of slags can be accurately measured up to temperatures as high as 1600 deg. C. This viscosimeter gives results which can be expressed in terms of specific viscosity, referred to that of water, or in terms of absolute C. G. S. units. A single run with the apparatus furnishes a temperature-viscosity curve over the entire temperature range desired. The principle employed depends upon the familiar law that, given two concentric cylinders—the space between being filled with the viscous liquid under examination—a torque proportional to the viscosity of the liquid is exerted upon the inner cylinder when the outer cylinder is rotated at a constant angular velocity. In the Bureau of Mines method this torque is measured accurately by suspending the inner cylinder by means of a calibrated steel or phosphor bronze suspension, and at the same time, weighting and damping the suspended system so that in its motion about its axis of rotation obeys laws similar to those governing the motion of a damped D'Arsonval galvanometer. The principle is not new, but one which has been strangely neglected and not hitherto used at elevated temperatures. Unlike the familiar Stormer viscosimeter, this new apparatus is entirely free from friction, measurements being made when the suspended system is in static equilibrium. Also, the liquid under observation is not deformed at any time, but is simply subjected to a uniform shear. Deflections may be read with extreme accuracy by means of a mirror and galvanometer scale, but for many practical purposes a pointer and graduated arc are sufficiently precise.

The method is applicable to substances possessing the most varied degree of viscosity, and, on account of the

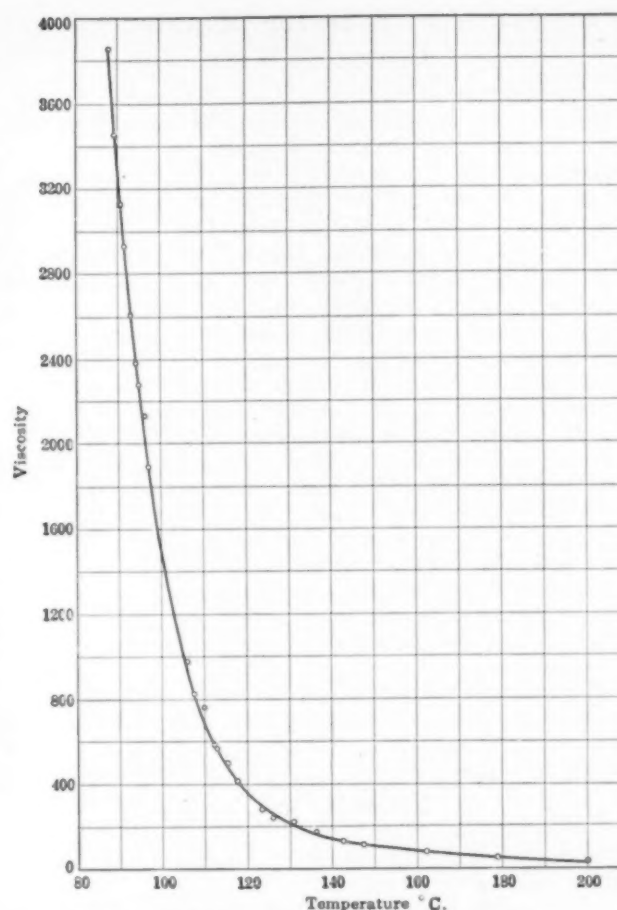


FIG. 1—TEMPERATURE-VISCOSITY CURVE OF AN ASPHALT PRODUCT

difficulty which has been hitherto encountered in estimating even approximately the viscosity of very viscous substances which do not permit of a ready passage through a capillary, finds a very fortunate application in the measurement of the viscosity of such materials as asphalt, pitch, heavy oils and petroleums, varnishes, polymerized organic products, resins, emulsions, colloidal substances, glues, greases, lards, vaselines, pasty mixers, paints, lubricants, and clay slips.

A well-known plate glass company evinced an early interest in the application of the high-temperature model of the Feild viscosimeter to the measurement of the viscosity of molten glass at high temperatures, and is taking steps to make use of the method in a technical way. The method is as readily applicable to the measurement of the viscosity of glass as that of blast-furnace slags. In fact the latter require a much higher operating temperature than do most glasses, and for this reason measurements on glasses are capable of more accurate temperature control and temperature measurement.

Fig. 1 shows the results of viscosity measurements made on a sample of a new type of asphalt, furnished by Dr. W. A. Hamor of the Mellon Institute for Industrial Research. Viscosity values are referred to the viscosity of water at 20 deg. C. as unity. These units are therefore equal to 1/100 C. G. S. unit. The apparatus was calibrated, not against water, but against a more viscous liquid of known viscosity, *e.g.*, castor oil, although glycerine, rape-seed oil, or liquid petrolatum might be used equally as well. The temperature-viscosity curve of this asphalt is seen to be a smooth one, with a maximum change of curvature in the neighborhood of 120 deg. C. (248 deg. Fahr.).

Chemical Control in the Manufacture of Enameled Ware

Although the Elyria Enameled Products Co. has maintained a chemical laboratory for more than five years, it has more recently realized the necessity for better facilities than were afforded under the early conditions. The contract for the new laboratory was let with Henry Shenk & Co. of Erie, Pa., about May 1, 1916, and the building has been in use since Sept. 1. It has brought forth so many favorable comments from the friends of the company that it seems worth while to give a brief description, together with an outline of the work carried on.

The new laboratory is located at the south end of the property owned by the company and faces on Taylor Street. It is of hollow-tile construction, 27 ft. by 30 ft., one story. It contains an office, balance and instrument room, and analytical laboratory. The latter is approximately 27 ft. by 18 ft. and is equipped with two 6-ft. hoods and 50 linear feet of table space.

In addition to the above building there is an experimental furnace room in connection with the factory proper, which, although not an actual part of the laboratory, is entirely given over to experimental and research work.

The accompanying illustration shows the exterior of the laboratory with the main office and a portion of the factory in the back-ground. The work which is carried on by this laboratory comes in general under two heads: first, operations which have to do with the manufacture and investigation of enamel, and secondly, the consideration of the wishes of the customers as related to enamel-lined products.

Under the first line of work come factory control and enamel development. The former involves the analysis of the steel and the various enamel raw materials, together with routine tests, both mechanical and chemical in nature, assuring a uniform product.

Research work is continually in progress, leading to the improvement of present formulæ and the development of new ones. Experimental batches are mixed, smelted, ground and burned on small trial dishes. Various tests of the physical and chemical properties of enamels are made and considerable work is done in the study of enamels under the microscope.

The relation of the laboratory to the trade has to do with the choice of proper formulæ to meet various conditions and the determination of the best methods of handling various kinds of material in enamel-lined

equipment. The customer is urged to furnish either a detailed statement of chemical conditions to which the enamel is to be exposed or samples of materials to be handled. The laboratory then proceeds to determine which enamel is best suited to the needs of the customers, and in cases where enamel-lined equipment will not be serviceable, reports to that effect.

Further than this, there are many problems arising relative to the proper handling of material. Various tests are run either on an experimental or a larger scale, involving the heating, cooling, condensation and agitation of various substances under consideration.

A New Automatic Oxygen Carbon Monoxide and Carbon Dioxide Recorder

In a large number of industrial plants urgent need has been felt for a recording instrument showing graphically and continuously the percentage of oxygen. Such a machine is illustrated and described below. It has been in actual use for some time and should be of interest to all plants that have limestone furnaces, cement kilns, etc., and to the oxygen manufacturing industry. It will immediately show the percentage of purity of oxygen, as well as any irregularities in charging the cylinders and thus prevent such accidents as have occurred recently in Chicago and San Francisco.

For this special purpose an instrument known as the "Mono" purity recorder has recently been placed in the market. This is graduated from 80 to 100 per cent and each per cent is of such wide range as to make fractions very clearly readable.

Fig. 1 is a general view of the recorder which in reality is a combination CO₂ and O recorder and may be used for either gas.



LABORATORY AT THE ELYRIA ENAMELED PRODUCTS CO.

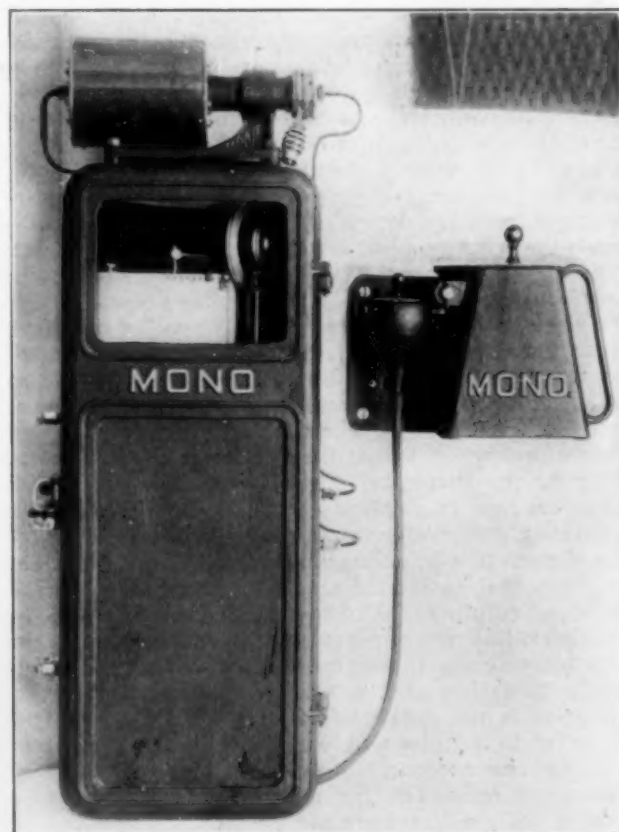


FIG. 1—GENERAL VIEW OF RECORDER

Fig. 2 is an interior view of the recorder. Except for the electric oven on top, the machine is a CO_2 recorder. Within the case, slightly to the right of the center line of the instrument, a valve will be noted, marked 1 and 2. With the valve in position 1 the gas will pass through a solution of KOH , thus absorbing CO_2 and switching off the electric oven. Position 2 allows the gas to pass through the electric oven, automatically started up and by-passing the vessel containing KOH . In this latter position of the valve the instrument acts as an oxygen recorder, while in the former position of the valve the instrument acts as a CO_2 recorder. A separate appurtenance is furnished to make the instrument record the percentage of monoxide.

In order to make the operation of the instrument clear it will be necessary to describe the working of the CO_2 recorder first as this is the basis upon which the instrument is built.

The absorption-apparatus is mounted in the lower part of the cast-iron cabinet, to which it is fastened by means of three screws in the bottom. The pressure-medium (water or air) by which the apparatus is driven passes through the regulating valve 1 (Fig. 3 and 4) and the pipe 2 into flask 3, which contains mercury. This is thus pressed up into the pipes, 4, 5, 6 and 8.

Pipe 4 is at the top connected with the burette in which the volume of the gas is ascertained. Pipe 5 is in communication with the outside air and the upper part of pipe 6 passes into an expansion of pipe 8 (Fig. 3) and 5 (Fig. 4).

The lower part of pipe 6 passes into the bottom of a recipient 2 and is thus only indirectly in connection with the mercury in flask 3. The position of this inner recipient 2 in flask 3 is such that the mercury in pipe 6 will always rise higher than that in pipe 5 or 8 (Fig. 3).

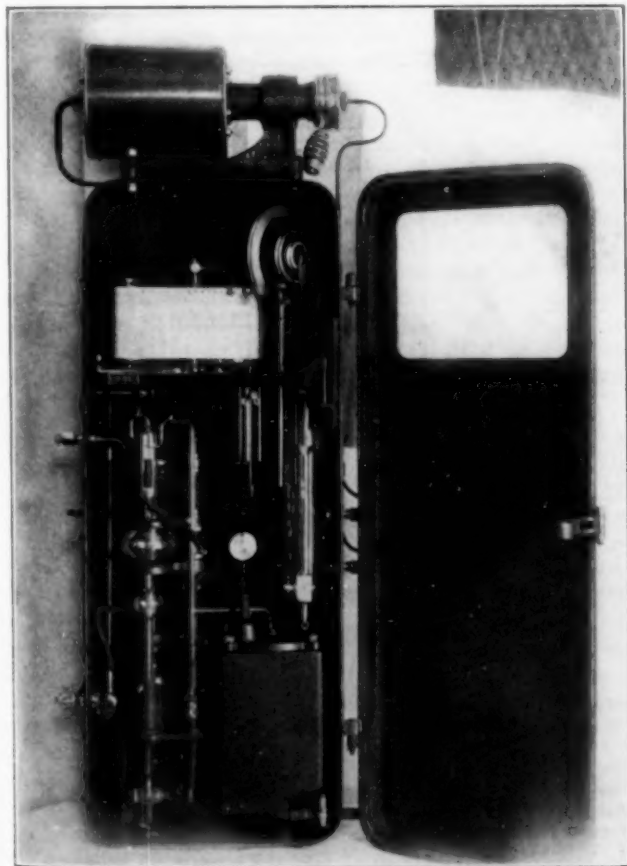


FIG. 2—VIEW SHOWING INTERIOR OF RECORDER

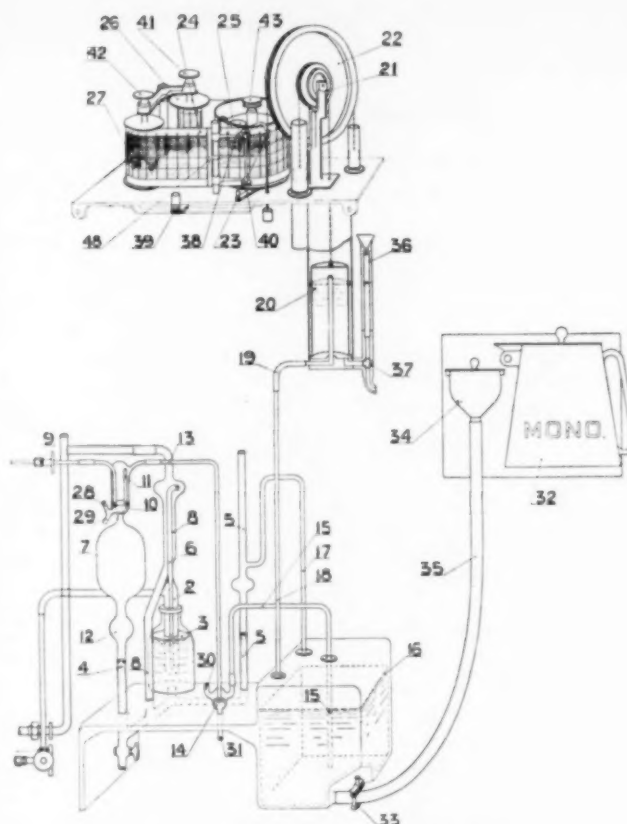


FIG. 3—DIAGRAM OF APPARATUS

As the pressure is increased, the mercury is finally forced out of the recipient 2 through pipe 6 and runs down into pipe 8 (Fig. 3) or pipe 5 (Fig. 4). As soon as pipe 6 is empty of mercury, the pressure-medium comes in contact with the outside air, and the excess pressure in flask 3 disappears. The mercury in pipes 4 and 5 then runs back into flask 3 filling it until some of it finally runs into the recipient 2. By this means the lower outlet of pipe 6 is closed. The pressure-medium is now no longer in contact with the outside air and the pressure rises again in flask 3 and the process above described is repeated. In this way an alternately rising and falling movement of the mercury is brought about, which movement is utilized in the following manner:

When the mercury sinks as above described, the gas to be analyzed is drawn in from the chimney through the filter and the tubing to the absorption-apparatus. Through the coupling 9, the mercury seal 10 and the pipe 11, this gas then passes into the burette 7, where it is measured, the pressure and temperature always being constant. When the mercury rises, the gas from the burette is pressed through pipe 13, the mercury seal 14 and pipe 15 into the recipient 16, which is filled with absorption-liquid. The carbonic or sulphuric acid in the gas is here absorbed, the remainder of the gas being pressed through pipe 18 up into the gasometer 20, which is shut off from the outside air by water.

When the gas enters, the gasometer rises and turns the wheel 21 which in its turn finally acts on the wheel 22. On this wheel and connected with it by means of a metal chain hangs the pen 23, which draws the curve on the diagram-paper 24. The lower extremity of the line produced indicates the percentage of gas absorbed.

When gas is drawn into the burette, pipe 17 comes in contact with the outside air, the gasometer then sinks back to its original position and the apparatus makes a new analysis and a new registration.

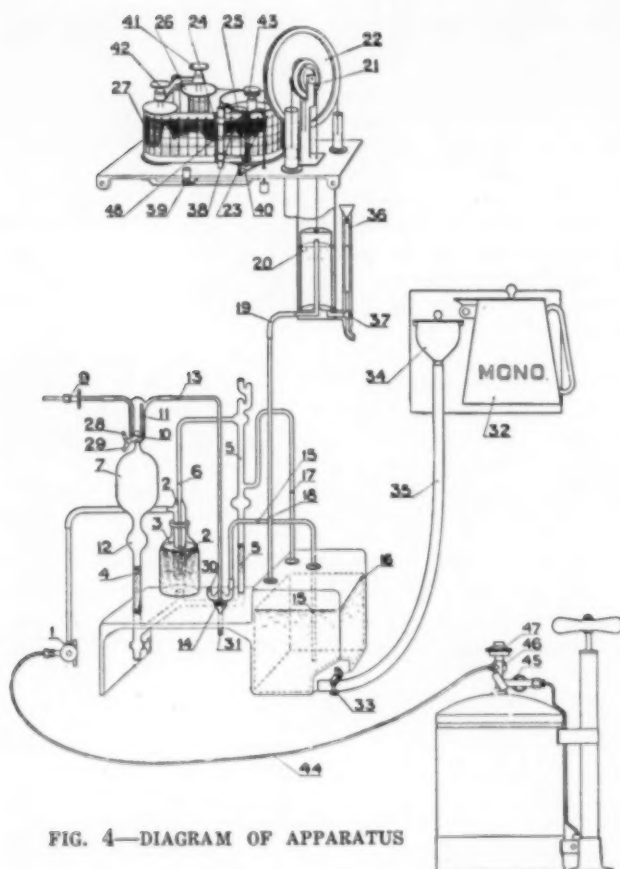


FIG. 4—DIAGRAM OF APPARATUS

The diagram is drawn from the roller 26 over the drum 25 by means of a clock in the latter, being afterwards automatically rolled up on the roller 27, or, at will, simply cut off.

In this manner the instrument will show either percentages of CO_2 , oxygen, or if desired CO on the same chart of very wide range. Up to 60 analyses can be made per hour with great accuracy.

The apparatus is being introduced into this country by F. D. Harger of 21 Park Row, New York City.

Barite in Northern Ontario.
—The world's largest barite deposit is situated in Langmuir Township on Night Hawk Lake, Northern Ontario, and is owned by the Premier Langmuir Mining Company. The deposit is estimated at 50,000 tons of the finest quality of barite and contains some silver. The occurrence of these two minerals simultaneously is a very rare one.

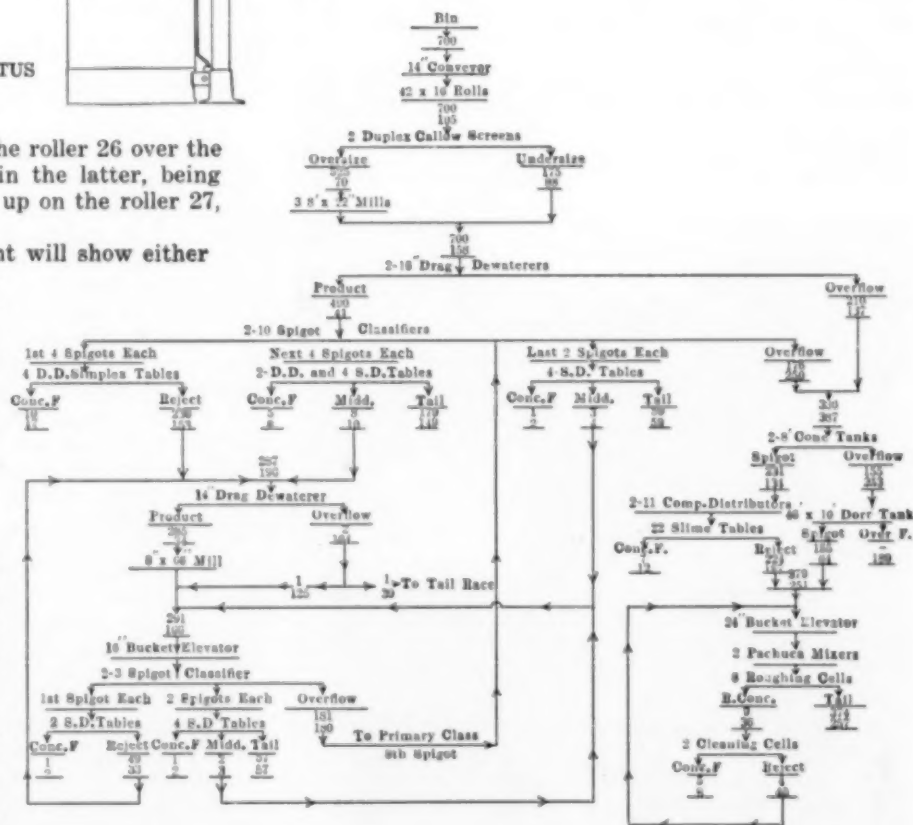
Barite is generally used in the manufacture of Scotch linoleums, white paint and hydrogen peroxide. As soon as it is possible to get the machinery on the ground a mill of from 30 to 50 tons' capacity will be erected. This mill requires special machinery.

Flow Sheet of Miami Mill

To supplement the report of the Arizona meeting of the American Institute of Mining Engineers in our last issue, we give on the bottom of this page the flow sheet of the Miami mill which was mentioned on page 492.

The dry tons milled from January to June, 1916, were 859,485, or 4722 tons per day. The copper in the feed averaged 2.09 per cent, of which 0.32 per cent was oxidized and 1.77 per cent was present as sulphide. The percentage of copper in the concentrates was 41.74. The total copper in the tailings amounted to 0.56 per cent, of which 0.30 per cent was oxidized and 0.26 per cent was present as sulphide. The recovery of copper was 74.06 per cent.

Philadelphia Studying Metric System.—The Philadelphia Bourse is conducting an investigation into the extent to which the manufacturers and commission merchants of Philadelphia must use the metric system in foreign business. An attempt is also being made to ascertain their attitude toward the national adoption of the metric system. Early results indicate that progressive concerns favor the metric system and officials of such companies as the J. G. Brill Co., Midvale Steel Co., Schuylkill Forge Co. and Tindel-Morris Co. have expressed themselves in favor of it.



Note: — Upper Figures are Tons Solids in 24 Hours
Lower Figures are Gallons Water per Minute
All "Conc F" are Finished to Bins. — Total Concentrate 30 Tons in 24 Hours
Carrying 51 Gallons Water per Minute
All "Tails" are Finished to Reclaimed Water Plant — Total Tailing 670
Tons in 24 Hours Carrying 730 Gallons Water per Minute Including
Dorr Tank Overflow and a Portion of 14' Drag Overflow.

FLOW SHEET OF THE MIAMI MILL

Personal

Mr. James L. Bruce, general manager of the Butte & Superior Mining Co., is on a trip through Tennessee, Missouri, Wisconsin and Illinois, inspecting the mines and smelters of the American Zinc, Lead & Smelting Co., in connection with the proposed merger of these companies.

Mr. Ernest Child has terminated his association with Eimer & Amend to join the firm of H. Reeve Angel & Co., Inc., New York City, as their president and general manager. Business friends of Mr. Child will be interested to know that among the activities of his new association is the sole representation on this continent of the manufacturers of the Whatman filter papers.

Mr. Noel Cunningham, metallurgical engineer, has moved his offices from 200 Fifth Avenue, to 90 West Street, New York City.

Mr. F. N. Flynn, for the past seven years connected with The Arizona Copper Company, Ltd., at Clifton, Ariz., has resigned his position as superintendent of the smelting department, effective Oct. 31. Mr. Roger H. Hatchett, who has been Mr. Flynn's assistant for six years past, has been appointed acting superintendent of the smelting department. Mr. Flynn will sail from New York early in November for Chuquicamata, Chile, where he will enter the employ of the Chile Exploration Company.

Mr. Ernest G. Jarvis has resigned his position as metallurgist with the Canadian Inspection and Testing Laboratories, to take a position as chief chemist and metallurgist with the McNab & Harlin Manufacturing Co., Paterson, N. J.

Mr. E. W. Kerr is to give up his professorship in mechanical engineering at Louisiana State University to take up commercial work with the Cuba Cane Sugar Corporation, Havana, Cuba.

Mr. M. G. Kopf, formerly chief engineer for the McCormick Laboratories at Dayton, Ohio, has opened a consulting engineering office at 602 Chemical Building, Chicago. Mr. Kopf has organized a staff which, in addition to regular consulting engineering work, will render a unique service in the chemical, electrical and mechanical patent fields. This service will differ from the ordinary patent service in that it will be based primarily on scientific engineering and manufacturing knowledge, combined with legal advice, rather than primarily on legal ability. Mr. Kopf has been chief engineer of the technical laboratories of the Automatic Electric Company and electrical engineer for the National Cash Register Company.

Mr. F. E. Marcy, inventor of the Marcy ball mill, has established offices in the Atlas Building at Salt Lake City, Utah.

Mr. E. P. Mathewson, general manager of the Washoe smelter of the Anaconda Copper Mining Co., has resigned, having accepted the position of general manager for the British-American Nickel Corporation.

Mr. R. Lewis Morris, vice-president of Herman & Herman, Inc., has sailed for England to open offices there for the corporation. Offices have already been established in Petrograd, Moscow, Genoa and Barcelona, and others will be opened in the Far East.

Dr. Charles L. Parsons, of the U. S. Bureau of Mines, and secretary of the American Chemical Society, has sailed for Europe to make a study of processes of extracting nitrogen from the air as successfully used in Norway. Visits will also be made to England, France, Sweden and Italy. The study is to be made as a preliminary step to the establishment

of the \$20,000,000 Government nitrate plant in this country.

Mr. Thos. B. Stearns of Stearns-Roger Manufacturing Co., Denver, Col., is touring the West on a business trip.

Mr. Charles E. Van Barneveld visited at Salt Lake City recently.

Mr. E. R. Weidlein has been appointed associate director of the Mellon Institute of Industrial Research at Pittsburgh. He has held an industrial fellowship since 1910 and has been in charge of hydrometallurgical investigations.

Mr. G. A. White, formerly metallurgist of the American Sheet & Tin Plate Company, is now associated with the Titanium Alloy Manufacturing Company of Niagara Falls, in the same capacity. Prior to his connection with the American Sheet & Tin Plate Company, Mr. White was for a considerable time with the Rock Island Railroad and also with the Eastern Steel Company, Pottsville, Pa., where he was engaged in the manufacture of structural material.

Book Reviews

The Flotation Process. By Herbert A. Megraw. Octavo (12 x 23 cm.), 249 pages, 48 illus. Price, \$2.50. New York and London: McGraw-Hill Book Company, Inc.

A timely and welcome sketch for the use of anyone interested in any way in ore dressing; this little book describes fully and accurately the rise, scientific principles and mill practice of this process. Admitting that the principles involved are being actively discussed, and that litigation is hampering the development of the process, yet frequent reports will be necessary to keep pace with its rapid progress, and the author must make a flash-light picture of the state at the date of his writing. This Mr. Megraw has done quite acceptably.

Practical Physical Chemistry. By J. B. Firth, M.Sc. Duodecimo (12 x 17.5 cm.), 178 pages, 74 diagrams. Price, \$1.00 net. New York: D. Van Nostrand Company.

This is a well-planned guide to student laboratory practice, animated by the thought that "one principle demonstrated by the student himself is of far more value to the student than pages of lecture notes." The sections cover thermostats, densities of gases, liquids and vapors, viscosity and surface tension, solubility, molecular weights, transition points, osmotic pressure, refractivity, rotary polarization, spectrum analysis, partition coefficients, thermochemical measurements, transport numbers, electrical conductivity, electromotive force, velocity of chemical reaction, quantitative electrolysis, electrolytic formation of salts, preparation of colloids.

The Heat Treatment of Tool Steel. By Harry Brearley. Second edition, octavo (12 x 22 cm.), 223 pages, 110 illustrations. Price, \$3.50 net. London and New York: Longmans, Green & Co.

A good book made better—a fine example of a particular topic handled by an expert, who knows what he knows and "sticks to his last." His experience is Sheffield experience, to which is added the refinements of the modern science of steel. Every maker and user of tool steel needs all the information there is in this book. It comes short of completeness in one or two directions, such as the handling of the rarer alloy tool steels, *e.g.* molybdenum steels, but this is apparently because the author's experience did not extend to them. Plate paper is used throughout, bringing out the photomicrographs beautifully.

INDUSTRIAL

Financial and Construction News

Financial

American Truss & Supply Company, Inc., has filed papers of incorporation at Albany, N. Y. The directors are J. Fisher, J. C. Gallup and S. C. Clark. The company is capitalized at \$20,000 and will deal in drugs and chemicals, trusses and supplies.

The Baumann Dyestuff & Chemical Company, Inc., Brooklyn, N. Y., has been incorporated with a capital of \$15,000. The incorporators are J. S. Mulroney, G. A. Rafferty and E. F. McGee.

The Bison Gas Corporation, Buffalo, N. Y., has been incorporated to produce petroleum, natural gas, by-products. The capital is \$25,000, and the incorporators are W. W. Sears, S. B. Nye and W. J. Brannen.

The Daniel Boone Oil Company has been incorporated to acquire lands containing oil, petroleum, gas, coal and other minerals, and develop same, and to refine and prepare oil for market. The capital stock is \$2,500,000. The incorporators are M. L. Rogers, L. A. Irwin and Harry W. Davis, of Wilmington, Del.

The Bristol Chemical Works, Bristol, Tenn., has been organized with a capital of \$50,000, and has begun work on a new plant, machinery for which has been ordered.

California Fertilizer Works has filed articles of incorporation at Fresno, Cal. The headquarters of the company are in San Francisco and the capital is \$100,000. Stockholders and directors are John Boyle, John Lacoste, Jacques Barelles, E. O. Riess and C. A. Artigues, all of San Francisco.

The Calkins Chemical Company, Pueblo County, Cal., has been incorporated with a capital of \$25,000. The incorporators are W. H. Warner, W. L. Hartmann and Z. H. Nelson.

The Clinton Oil & Manufacturing Company, Clinton, S. C., has been purchased by a stock company for \$30,000, and business will be conducted under the name of the Clinton Oil Mill.

The Commonwealth Chemical Corporation, 1500 Garden Street, Hoboken, N. J., has been incorporated to make and sell dyes, chemicals, drugs, paints and oils. The capital stock is \$25,000. The incorporators are Fritz G. Stockelbach, Edward A. Walsh and Carl Schaetza.

The Connecticut Brass Corporation, with \$2,000,000 capital, has been incorporated to carry on the business of brass manufacture. The incorporators are Herbert E. Latter, Norman P. Coffin and Clement M. Egner, of Wilmington, Del.

The Consolidated Rolling Mills & Foundries Company, Inc., is a new incorporation formed with a capital of \$1,000,000 to deal in merchandise of all kinds. Herbert E. Latter, Norman P. Coffin and Clement M. Egner, of Wilmington Del., are the incorporators.

The du Pont Powder Company and the Etna Explosives Company have announced that they will convert their explosives factories into factories for manufacturing intermediates and dyestuffs when the demand for explosives becomes normal. The change to making intermediates would not involve a great deal of expense, as much of the same apparatus is used. Just what will be done as to finished dyes is not known.

The Electric Steel Company, St. Paul, Minn., has recently been organized with a capital of \$300,000, and plans building a factory in St. Paul. The incorporators are G. W. Harrison, Max Toltz, J. H. Dalton, J. C. Pettibone, H. F. Hamilton, Louis Payer and C. C. Haupt.

The Epoch Company has been incorporated at Dover, Del., with a capital of \$1,200,000. The company will manufacture and sell medical preparations. The incorporators are M. L. Rogers, L. A. Irwin and Harry W. Davis, all of Wilmington.

The Filer Fibre Company, Detroit, Mich., has been organized with a capital of \$300,000, and plans the erection of a pulp plant at Manistee, Mich. E. G. Filer is president.

The Gillmore Fire Clay Company has been incorporated at Pittsburgh by A. L. Gill, C. A. Bursner and D. E. Mitchell.

The Hoffman Oil & Refining Corporation has filed articles of incorporation at Dover, Del. The company has a capitalization of

\$10,000,000 and was formed to acquire and develop oil lands and build oil tanks. The incorporators are Ferris Giles, L. S. Dorsey and K. M. Dougherty, all of Wilmington.

The Homes Oil Refining & Gas Company, capitalized at \$250,000, has filed articles of incorporation in Utah. The company plans the development of oil and gas resources along the shores of the Great Salt Lake. The officers are Alvin F. Smith, president; Levi M. Harmon, secretary-treasurer; H. L. Nelson, H. A. Langford, H. W. Horn, John T. Neff and John J. Van Allen, directors.

The Industrial Oil Company, Inc., Syracuse, N. Y., has been incorporated in New York State to deal in oil products. The capital is \$5,000, and incorporators are H. D. Brockett, E. H. Goodrich and H. T. Butler.

The Ion Dyes Company, Wilmington, Del., has been incorporated to manufacture, sell and deal in and with chemicals, dyes, etc. The capital is \$150,000. The incorporators are Herbert E. Latter, Norman P. Coffin and Clement M. Egner.

The Jap-Ammonia Company of Rochester, has filed a notice at Albany of an increase in stock from \$40,000 to \$100,000.

The Joy Products Company, Inc., 68 William Street, New York, has been incorporated to deal in washing powders and chemicals. The capital is \$10,000 and the incorporators are B. B. and E. A. McAlpin, and F. B. Robinson.

Kugel-Miner-Morse, Inc., is the name of a new company which has been organized at Erie, Pa. The incorporators are Henry Kugel, Pierre A. Miner and Henry L. Morse, of Erie, Pa. The company will deal in iron, lead and other metals, shop and mill supplies, tools and machinery.

The O. C. F. Leddin Company, of New York City, has been organized with a capital of \$10,000 to manufacture chemicals. Otto C. F. Leddin and Max Voetter, of Brooklyn, are directors.

The David Lupton's Sons Company, a Pennsylvania Corporation manufacturing iron and steel, has been authorized to transact business in Indiana. Philip W. Frey, Evansville, Ind., is agent. Part of the company's capital is represented in Indiana.

The J. D. McQuade Chemical Company, 75 Montgomery Street, Jersey City, N. J., a new company, will make and sell chemical products and will take over the business formerly conducted by the Phenol Products Company. The capital stock is \$125,000. The incorporators are J. D. McQuade, James J. Higgins and Thomas Falon, Jr.

The Mansfield Foundry Company, Mansfield, Mass., has been incorporated with a capital of \$15,000. The directors are J. M. Bullard, president; Arthur B. Colvin, treasurer, and P. D. Dean.

The Marine Engineering Corporation has been incorporated to manufacture, operate, sell and deal in and with steel, iron, machinery, tools, etc., to construct boats, barges of all kinds, manufacture munitions of all kinds. The capital is \$10,000,000. The incorporators are Joseph N. Folwell, of Edgewater, N. J.; Mathew J. Wheeler and Hugh S. Hemingway, of New York.

The Eli Marks Dye Manufacturing Company, New York, has been incorporated with a capital of \$100,000. The incorporators are D. Graef, M. and E. Marks.

The G. H. Mead Company, paper manufacturers, of Cincinnati, Ohio, has increased its capital from \$50,000 to \$100,000 to meet increased trade.

The Metallic Chemical Company, Utica, N. Y., has been incorporated with a capital of \$100,000. The directors are William E. Lewis, Alfred M. Thomsen and Arthur J. Foley, of Utica.

The Mount Holly Paper Mills, Inc., has been incorporated under the laws of Massachusetts with a capital of \$550,000. This company will operate the Mount Holly Paper Mills at Mount Holly Springs, Pa., which has been idle for six years.

The New York Color & Chemical Company, Inc., 210 West 107th Street, New York, capital \$100,000, has been incorporated to deal in chemicals, dyes and paints. The incorporators are T. F. Kelly, L. W. Neimisch and J. C. Donavin.

The Nitro-Tungsten Lamp Company, Providence, has been incorporated with a capital stock of \$50,000. The incorporators

are William L. Studley, John E. Canning and Henry C. Hart, of Providence.

The North East Foundry & Machine Company, North East, Pa., has been incorporated at Pittsburgh with a capital of \$25,000. The incorporators are Edmund A. Finerty and Frank G. Pottmeyer, of North East; William G. O'Malley, of Midland, and John J. Finerty, of Buffalo.

The Oil Refineries Direct Service Company, Inc., 128 Maiden Lane, New York City, has been incorporated to deal in lubricating oils, greases, soaps, paints, varnishes and engineers' supplies. The capital is \$10,000 and the incorporators are G. P. Francis, I. M. Reynolds and J. H. Weinberg.

The Oriana Fertilizer Company, Norfolk, Va., is a new corporation. The capital is \$50,000. J. W. Callis is president.

The Palma Sugar Company, of Greenwich, Conn., has increased its capital stock from \$1,400,000 to \$2,960,000.

The Palmirito Sugar Company has been incorporated in Delaware by New York and Wilmington capitalists.

The Philadelphia Dyeing & Finishing Company, Inc., has been incorporated under the laws of New York State to dye, color and otherwise treat goods and fabrics. The capital is \$100,000 and the incorporators are A. W. Hardwick, W. J. Gibbons, Jr., F. Merz. The office is at 257 Fourth Avenue, New York City.

The Pittsburgh-Utah Potash Company has been incorporated to engage in the business of mining and manufacturing potash, aluminium, gold, silver, copper and other metals. The capital stock is \$250,000. The incorporators are F. D. Buck, M. L. Horty and M. E. Noblit, of Wilmington, Del.

The Satterfield Barytes Company, Cartersville, Ga., has been organized with a capital stock of \$10,000.

The S. P. M. L. Manufacturing Company, Inc., 64 Franklin Street, Astoria, L. I., New York, has been incorporated to manufacture machinery, specialties, novelties, chemicals and compounds. The capital is \$10,000. The incorporators are P. E. Taylor, W. W. Harton and P. H. Seaman.

The O. G. Schmid Chemical Company, of Jackson, Mich., has increased its capital from \$250,000 to \$370,000.

The Scobell-Mill Chemical Company, Inc., Rochester, N. Y., has been incorporated to deal in chemicals, drugs and factory supplies. The capital is \$10,000, and the incorporators are A. H. and A. H. Miller, Jr., and G. W. Scobell.

F. Slobotzky, Inc., 154 Nassau Street, New York City, has been incorporated to deal in chemicals, products, dyestuffs, extracts, drugs, merchandise. The capital is \$10,000, and the incorporators are W. Saenger, A. Seligman and I. Slobotzky.

Solvay Coke Company will hold a stockholders' meeting at Ashland, Ky., Nov. 1, in order to pass on a proposition to increase the common stock from \$1,300,000 to \$2,500,000. The increase is to be used for additional coal lands and the development of the company's coke plant.

Somers Company, Inc., Waterbury, Conn., has been incorporated to manufacture metals and machinery. The capital is \$50,000. The incorporators are Joseph E. Somers, Robert D. Somers and Louis J. Somers.

The Suriman Trading Company, Ltd., New York City, has been incorporated to act as commission merchants and agents in lumber, wood, paper and pulp. The capital is \$100,000, and incorporators are G. R. Foody, L. J. Ingeoine and W. H. Thomas.

The Tacoma Lime Products & Fertilizer Company, Tacoma, Wash., has been incorporated in Washington with a capital of \$50,000. The incorporators are J. B. Agner, I. Carpenter and L. Y. Staton.

The Taylor Instrument Company, Rochester, N. Y., have increased their capital from \$535,000 to \$2,500,000.

The Telluride Mines Corporation has been incorporated in Delaware with a capital of \$500,000 to carry on a general mining business. The incorporators are Bertram Scheuer, Frank T. Inch and Samuel Straus.

The Thrall Oil Refining Company, Thrall, Tex., has been incorporated at Austin, Tex., with a capital of \$20,000. The incorporators are Fritz Fuchs, L. W. Fuchs and F. C. Klotz.

The Transport Oil Corporation, 43 Cedar Street, New York, has been incorporated. The incorporators are R. G. Coad, J. A. New York State with a capital of \$20,000. Lederman and B. Lockwood.

Trumbull Steel Company, of Warren, Ohio, directors have authorized the issuance of \$3,750,000 common and preferred stock to take care of plant extensions.

The Tungsten-Gold-Silver Production Company, Boulder County, Col., has been

incorporated at Denver, Col., with a capital of \$100,000. The incorporators are H. R. Moodie, A. R. Pattee, N. M. Abbott.

The Tygerine Oil Company has been incorporated to manufacture and deal in oils and compounds. The capital stock is \$200,000. The incorporators are Ferris Giles, K. M. Dougherty and L. S. Dorsey, of Wilmington, Del.

United Alloy Steel Corporation, New York City, has been incorporated with a capital of \$2,625,000. The incorporators are H. Bennett, Jr., W. K. Dupree, Jr., and R. Sherman.

The United States Drug & Chemical Company, Cleveland, is a new corporation with a capital of \$250,000.

The United Steel Company of Canton, Ohio, has been sold to a New York syndicate, headed by Hornblower & Weeks, bankers, for \$16,000,000. About \$4,000,000 will be spent in improvements and the name will be changed to the United Alloy Steel Company.

The Utility Distributing Company, Wilmington, Del., has been incorporated to deal in and manufacture chemicals, compounds, combinations to be used in removal of carbon and prevent formation of carbon. The capital is \$1,000,000. Representative, C. J. Coleman, 1465 Broadway, New York City.

The Washington Copper Company, Seattle, Wash., has been incorporated in Washington with a capital of \$1,000,000. The incorporators are Joseph Silver, L. J. Riley, Charles Osmer and F. A. England.

West End Oil & Gas Company, Wilmington, Del., has been incorporated to acquire oil and gas lands and to develop them. The capital is \$1,200,000. The incorporators are F. D. Buck, George W. Dillman and M. L. Horty.

The Western Glass Company, St. Marys, W. Va., has been incorporated with \$50,000 capital to manufacture glass.

The Western Process Company has been organized at Portland, Me., with a capital of \$50,000. The company will carry on the business of mining, milling, smelting and refining of various metals, gypsum and coal. The officers are Frederick H. Cobb, president; Carl W. Smith, treasurer, both of Portland, Me.

The Weston Glass Company, of Pittsburgh, Pa., has been incorporated at Cincinnati, Ohio, with a capital of \$50,000. The incorporators are R. S. Glese, Charles V. Arbogast, F. W. Stonecipher, L. K. Voelker, of Pittsburgh, and Van J. Kuntz, of Jeanette, Pa.

The West Virginia Waste Wood Chemical Company, Inc., has been incorporated to develop processes and machinery for destructive distillation of wood and other raw materials, with a capital of \$330,000. The incorporators are H. M. Ward, R. Kirby and W. M. Baldwin. The office is at 17 Battery Place, New York.

White Cross Copper Company, Wilmington, Del., is incorporated to manufacture, sell and deal in and with gold, silver, copper, etc. The capital is \$1,000,000. The incorporators are F. D. Buck, M. L. Horty and K. E. Longfield.

Wilcoff & Vaughn Company, Inc., New York City, has been incorporated to manufacture iron, steel, mining and railway equipment. The capital is \$25,000, and the incorporators are M. L. Welland, A. H. Slack and H. Amerman.

The Wright Chemical Corporation, Newark, N. J., has been incorporated to manufacture chemicals. The capital is \$100,000 and the incorporators are Elma J. Wright, Anna G. Wright and Anna C. Crocker, of Brooklyn.

Construction and Operation

Alabama

BIRMINGHAM.—The Linde Air Products Company has given contract for the erection of a plant to produce oxygen at Birmingham, Ala.

California

FAIR OAKS.—The Fair Oaks Fruit Company has decided to spend from \$12,000 to \$15,000 during the next year in enlarging the plant. The ripe olive process plant will be increased and a solvent plant for the saving of the grease in the olive seeds will also be constructed.

LONG BEACH.—The Marine Chemical Corporation, which has been operating a plant here for some months, will increase its capital from \$60,000 to \$300,000 and build a large factory in the harbor district

for the manufacture of products from the waste bittern water from salt refineries. The officers of the company are J. M. Kern, president of the California Southern R. R.; S. E. Muesser, chemist, and C. T. Whittier, president of the United Oil Company. The plant is located near the Long Beach Salt Works.

LOS ANGELES.—The Warman Steel Casting Company of Los Angeles, Cal., has announced the erection of three foundry buildings at Huntington Park, to cost \$100,000. The company's plant at Redondo Beach will be moved to the new location.

OAKLAND.—The Paraffine Paint Company, Oakland, Cal., has practically doubled its capacity by additions to its plant.

PETALUMA.—Monte Button of San Francisco has purchased land on the waterfront and intends to erect a paint factory.

SAN MATEO.—The Whitney Chemical Company has commenced the manufacture of epsom salts, magnesium chloride and potassium chloride from sea water at San Mateo, Cal. The company is working in conjunction with the Leslie Salt Refining Company. Sea water is evaporated in ponds and the salt removed, and the potassium and magnesium salts are obtained from the remaining liquor.

Connecticut

CANAAN.—The Connecticut Chemical Company, of which William M. Barnum, of New York, is the head, will erect a wood distillation plant at Canaan, Conn., for the manufacture of acetate of lime and wood alcohol. The cost of the plant is estimated at \$250,000.

NEW HAVEN.—The Baumann Rubber Company, New Haven, Conn., has awarded the contract for the erection of a new three-story factory, 75 by 32 ft., to cost \$20,000.

District of Columbia

WASHINGTON.—Bids will be received at the Bureau of Supplies and Accounts, Navy Department, Washington, D. C., for furnishing at the various navy yards and naval stations supplies as follows: Mare Island, Cal., Schedule 293—one automobile ambulance; Schedule 297—1000 5-cp. instrument lamp sockets 2000 lb. copper pipe. Puget Sound, Wash., Schedule 297—six engine room clocks, 285 lb. 20-in. by 48-in. hard sheet rubber; Schedule 294—six 220-volt, alternating-current motors. Charleston, S. C., Schedule 316—two engine room and fire room clocks, one steam-driven air compressor, two indicators for auxiliary engines, one steam whistle. F.o.b. works, Schedule 310—200,000 minor caliber tracer fuses. Washington, D. C., Schedule 311—8000 lb lead wire, 10,000 lb. soft copper sheets, in strips, 4100 ft. galvanized iron pipe. Brooklyn, N. Y., Schedule 305—miscellaneous interior communication cable, 10,500 ft. telephone cable, 12½-in. portable electric drills, 12 double scale portable voltmeters, miscellaneous twin-conductor wire. Various, Schedule 289—\$300 ½-in. to ¾-in. spark plugs. Norfolk, Va., Schedule 303—miscellaneous brass sheet, 40,000 lb. manganese ingot bronze, miscellaneous copper bar, 150,000 lb. ingot copper, miscellaneous sheet copper. Applications for proposals should designate the schedule desired by number.

Illinois

CHICAGO.—Swift & Company has announced that it would erect a 7-story soap factory to cost \$200,000.

Indiana

GARY.—The American Car & Foundry Company will erect a large plant at Gary, Ind., to employ 4000 men. Actual construction will not be commenced until early in the winter.

GARY.—The U. S. Steel Corporation plans to make vast extensions at Gary, Ind., according to information disclosed in a recent case in the Circuit Court at Valparaiso, Ind. Suit was brought against subsidiaries of the steel corporation by trustees of the Mandel estate to have the Grand Calumet River restored to its original contour, to connect it with Gary Harbor and open it to the public. The corporation contends that it had to change the river to build its plant, and that it is impracticable to use the harbor for general commercial purposes. During the hearing it was disclosed that four new furnaces will be built, also a new Bessemer duplexing mill. The National Tube Company will erect four blast furnaces, docks, a Bessemer mill and auxiliaries. The American Locomotive Company and the American Car & Foundry Company have acquired sites for new plants in Gary.

MUSKOGEE.—Officials of the Ball Glass Manufacturing Company, of Muncie, Ind., recently visited Muskogee in order to obtain information on the gas fields relative to

the establishment of a glass factory. The Ball Glass Manufacturing Company is one of the largest manufacturers of glass jars in the world, and has a large plant at Muncie, Ind. The officials of the company are E. B. Ball, president; F. C. Ball, vice-president, and Fred Jewett, general manager of the glass department.

Kentucky

LOUISVILLE.—The Security Producing & Refining Company, Louisville, Ky., is planning the erection of an oil refinery.

Louisiana

BOGALUSA.—Construction has been started at Bogalusa, La., of a large paper mill; cost about \$1,000,000. It will have a capacity of 75 to 90 tons of paper per day, and is being erected by the Bogalusa Paper Company, of which G. H. Wood is the head.

Maryland

BALTIMORE.—The Columbia Paper Company, Baltimore, Md., will erect a new addition to its East Fort Avenue plant. Plans have not yet been given out.

BALTIMORE.—The Penn Mary Steel Company, Baltimore, Md., is having estimates prepared for the erection of an addition to their gas engine plant, which will cost when equipped about \$400,000. The new addition is to be of brick and fireproof construction, one story high. It will have dimensions of 90 by 200 ft. The engines which will be installed in the new addition will be used in connection with the blower system of the steel works.

CANTON.—The Coco-Nut Oil Products Company, a New York corporation, has let the contract for the erection of a plant at Canton, Md., to cost \$150,000. Extensive machinery and equipment will be installed for the extraction of oil from cocoanuts.

SPARROWS POINT.—The Bethlehem Steel Company will erect a by-product coke plant at Sparrows Point, Md., to cost \$2,500,000. The H. Koppers Company is preparing the plans.

Massachusetts

BOSTON.—The Revere Sugar Refining Company, Boston, Mass., is preparing plans for a new group of buildings at Charlestown. One of the largest buildings will be nine stories high of brick, steel and stone, and will cost \$280,000. A filter house will also be built, nine stories high and 101 by 72 ft., costing \$161,000. A six-story brick, steel and stone building, to be known as the melter house, will also be erected. This will cost \$40,000.

PALMER.—The Whittall Carpet Mill, Palmer, Mass., has let the contract for a dyehouse to cost \$12,000. The building will be one story high, 110 by 40 ft.

Michigan

BENTON HARBOR.—The Superior Steel Castings Company's new plant is rapidly nearing completion. The steel skeleton work is finished, and although considerable difficulty was encountered in securing cars to haul sand for filling, it is expected that the plant will be finished by Dec. 1.

DETROIT.—The John A. Crowley Steel Company is erecting an electric steel plant in Delray, a suburb of Detroit. Grönwall-Dixon furnaces will be used.

HOLLAND.—The Holland Aniline Company will shortly start operations at its new plant and expects to turn out Bismarck brown. The company has its own power house, pumping station and gas plant. The manufacture of methyl violet and methylene blue is also contemplated.

HOLLAND.—The Holland Furnace Company, Holland, Mich., is erecting a new foundry, 60 x 230 ft., adjacent to its present buildings. The new foundry will double the company's capacity and add 100 men to its force. Mr. A. H. Landwehr is manager of the company.

MANISTEE.—The Filer Fibre Company, a newly organized company, plans the erection of a pulp plant to be completed within eight months.

Minnesota

BEMIDJI.—A modern foundry is being erected by the Bemidji Welding & Machine Company, Bemidji, Minn., to manufacture all kinds of iron, brass and aluminum castings. The output will be three tons per day.

ST. PAUL.—Plans are under way by the Electric Steel Company, a new concern, for a steel manufacturing plant to make electric furnace steel castings. Ten acres have been

purchased at Lexington Avenue and Great Northern Railroad. G. W. Harrison is president of the new company.

Missouri

ST. LOUIS.—The Lincoln Steel & Forge Works has acquired four acres of land at Natural Bridge and Goodfellow Avenue, and is erecting buildings for the manufacture of structural steel.

Montana

HAMILTON.—The Montana-Utah Sugar Company has ordered the machinery for its new factory at Hamilton, Mont. This will be delivered next March. The contract for structural steel work has been let.

New Hampshire

FRANKLIN FALLS.—M. T. Stevens & Sons, Lawrence, Mass., have let the contract to the J. W. Bishop Company, of Worcester, for a new dyehouse at its Franklin Falls, N. H., plant, to cost \$30,000.

New Jersey

MARCUS HOOK.—A two-story factory building will be erected at Marcus Hook for the Benzol Products Company, at a cost of \$35,000. The contract has been let to F. W. Van Loom.

MILLVILLE.—The Millville Manufacturing Company, Millville, N. J., which employs about 500 hands in their bleach and dye works, has given the contract for a large concrete plant which will almost double its capacity.

NEWARK.—An addition will be made to the plant on the Hackensack River of the White Tar Company of New Jersey, at a cost of \$30,000. The concern will refine naphthalin.

PATERSON.—The Standard Oil Company of New Jersey will erect a new distribution station at Paterson, N. J., to cost \$100,000. There will be nine buildings, the largest being 75 by 100 ft. The contract has been awarded to the H. D. Best Contracting Company. Samuel B. Farnum is Paterson manager of the Standard Oil Company.

PATERSON.—The Victory Silk Dyeing & Finishing Company, Paterson, N. J., is erecting a one-story mill to cost \$42,800.

TRENTON.—The New Jersey Chemical Company, 145 North Willow Street, Trenton, N. J., is operating a process for the recovery of zinc from scrap galvanized iron, with the production of zinc oxide, and zinc free scrap iron. The officials of the new company are Thomas Shegog, Abraham Bersek and David Berkow.

New York

BROOKLYN.—The W. Beckers Aniline and Chemical Works, Brooklyn, N. Y., manufacturers of dyestuffs, will hold a stockholders' meeting on Nov. 2 for the purpose of voting on a stock increase from \$2,000,000 to \$5,000,000 for the purpose of enlarging the plant.

BUFFALO.—The Commercial Electrolytic Corporation, a new company, has acquired a site in Buffalo and will erect a factory for the manufacture of hydrogen peroxide. About 1000 hp. of electrical energy has been contracted for.

BUFFALO.—The Schoelkopf Aniline and Chemical Works are having two three-story factory buildings erected at a cost of \$40,000.

CARTHAGE.—The Island Paper Company will build a sulphite mill at Carthage, N. Y., on what is known as Tannery Island. The cost is approximately \$100,000. The building will be two stories, 88 by 79 ft. Charles W. Pratt is owner of the company.

COHOES.—The Frank Gilbert Paper Company has let a contract to C. P. Boland & Company, of Troy, N. Y., for the erection of a paper plant at Cohoes, N. Y. The new plant will cost about \$100,000. It will include a machine shop, finishing mill, sulphite mill and power house. The plans were formulated by Thomas L. Tomlines, consulting engineer of Watertown. Brick and steel construction will be used and the most modern equipment will be installed.

DUNKIRK.—The Dunkirk Glass Company, of Dunkirk, N. Y., has announced that it will double the size of its plant. The principal addition will be a two-story building, 80 by 200 ft. The new furnaces will add at least 50 men to its force.

HUDSON FALLS.—The Union Bag & Paper Company will erect a new plant at Hudson Falls, N. Y., adjacent to its present factory. The new building will be 400 by 100 ft., and will employ about 400 persons.

JOHNSON CITY.—Construction will be commenced in March, 1917, by Endicott,

Johnson & Company, Johnson City, N. Y., of an immense sole leather tannery to cost \$750,000. The new tannery will be located to the west of the present sole leather tannery and will have a capacity of 4000 sides per day. The present sole leather tannery has a capacity of 2800 sides per day. A new power plant will also be built. George W. Johnson, superintendent of tanneries, is now in the West inspecting large tanneries for the purpose of obtaining ideas on construction.

LONG ISLAND CITY.—The Cambridge Silk & Chemical Company has purchased a site at Harris Avenue and Hamilton Street, Long Island City, and will shortly erect a plant.

NEW YORK.—Richmond Levering & Co., 120 Broadway, New York, contemplate the erection of a potash plant on the Hudson River to cost \$1,000,000. Sketches are being prepared by J. Norman Bulkley, architect and engineer. The exact location has not yet been made public.

NIAGARA FALLS.—The Carborundum Company will erect an administration building on the property of the Niagara Falls Power Company. The present offices will be used as a research laboratory by the Massachusetts Institute of Technology in conjunction with its new course in chemical engineering practice.

NIAGARA FALLS.—Almost all of the output of the new \$2,000,000 steam-electric plant of the Buffalo General Electric Company, at Niagara Falls, has been contracted for within 25 miles.

Ohio

COLUMBUS.—The Ohio Malleable Iron Company, Columbus, Ohio, is erecting an addition to its plant on the North Side, to cost \$70,000.

COSHOCOTON.—The Coshocot Glass Company, Coshocot, Ohio, is having plans prepared by H. L. Dixon & Company, of Pittsburgh, for a new bottle factory, to cost \$100,000, and employ 150 men. The new factory will increase the capacity of the plant to 150,000 bottles per year.

LORAIN.—The J. C. Cromwell Steel Company, of Cleveland, Ohio, has let contracts for its new steel mill to be erected at Lorain, Ohio. The blooming mill will be built by the Alliance Structural Company, the cranes by the Alliance Machine Company and other work by the Eastern Steel Company.

LORAIN.—The United States Steel Corporation is considering plans for the erection of a new steel plant here to employ 6000 men.

MASSILLON.—The National Pressed Steel Company plans the erection of a new plant in Massillon, Ohio, to manufacture hot and cold-rolled strip steel and metal lumber. The new company is allied with the Massillon Rolling Mill Company and the Central Steel Company of Massillon. R. E. Bebb is president of all three companies.

NILES.—The Fostoria Glass Works has begun the erection of a new addition to its plant, which will increase its capacity more than one third. N. J. McMahon is superintendent of the plant.

NILES.—Work is progressing satisfactorily on the construction of the new plant of the Grasselli Chemical Company, a short distance west of Niles.

NILES.—The Niles Glass Works, Niles, Ohio, a subsidiary of the National Electric Lamp Company, has awarded to the Austin Company, of Cleveland, a contract for a new building to cost \$50,000.

WARREN.—The Trumbull Steel Company, of Warren, Ohio, will erect ten new open-hearth furnaces of 100 tons capacity each, and also a 40-in. blooming mill and bar mill. The United Engineering & Foundry Company will furnish the mills and the Ritter-Conley Company the steel.

YOUNGSTOWN.—A new battery of by-product coke ovens is contemplated by the Republic Iron & Steel Company, of Youngstown, Ohio. Plans have been prepared for a battery of forty-six or forty-seven ovens which will bring the capacity up to 3000 tons daily, and the ovens up to 190. The installation will cost \$1,000,000 and everything is ready for the directors to authorize the extension. Mr. J. W. Deetrick is general manager of the company.

Oklahoma

ADA.—A new glass factory to manufacture fruit jars is contemplated at Ada, Okla. Fruit jar manufacturers from Wichita Falls, Tex., have been looking over the natural gas fields.

OKLAHOMA.—The Oklahoma Refinery Company, Okla., will erect a new warehouse costing \$30,000, to replace buildings recently destroyed by fire. Mr. K. R. McKee is president of the company.

Oregon

WILLBRIDGE.—The Pacific Coast Steel Company has selected a site in Willbridge, Ore., for its proposed plant after months of negotiation. The property lies just north of the plant of the Shell Oil Company, and comprises fifteen acres.

Pennsylvania

BRIDESBURG.—The Abrasive Metal Company will erect a new crushing plant at Bridesburg, Pa., consisting of a building 82 by 86 ft.

GLENSHAW.—A site has been purchased here by a West Virginia glass manufacturing firm and it is the intention to erect a modern glass plant. The land was purchased through the McConnell Company, of Pittsburgh.

MOUNT UNION.—The plant of the Aetna Explosives Company, at Mount Union, Pa., which has been idle for some time, will be used for the manufacture of dyes and sulphuric acid.

PHILADELPHIA.—The Henry Bowker Chemical Company will erect a one-story brick shop, 50 by 60 ft., to cost \$3,000.

PHILADELPHIA.—The Chamber of Commerce of Philadelphia has given out the information that two great metal plants, employing 10,000 men, would shortly locate there. The names of the concerns and the exact nature of the work have not yet been made public. River and rail facilities, the presence of skilled labor and proximity to raw materials were deciding factors.

PHILADELPHIA.—A large iron foundry will be erected on the Schuylkill River, Thirtieth Street, below Locust, Philadelphia, Pa., by Morris, Wheeler & Company. The property known as the "old paper mill plant" has been acquired. This property was formerly owned by the Continental National Bank of New York.

PHILADELPHIA.—Three buildings, one 150 by 50 ft., and two smaller, will be erected at the northeast corner of Sixty-first Street and Eastwick Avenue by the H. A. May Foundry Company.

Texas

BAY CITY.—Plans for the erection of a peanut-oil mill are being made by V. H. Sledge, Bay City, Tex.

TEXAS CITY.—The Texas Resources Development Company is considering plans for the construction of blast furnaces and a steel plant to handle ore from Cass County, Tex.

Utah

OGDEN.—The Continental Oil Company plans to erect a new plant to cost \$40,000 on land recently purchased. The plant will consist of a two-story concrete and brick warehouse, pump house and six new tanks, with a combined capacity of 200,000 gal. Joseph F. Campbell is superintendent.

Virginia

FREDERICKSBURG.—The National Dye Corporation of New York will begin the manufacture of dyes at Fredericksburg, Va., in a short time. The company has acquired the plant of the Sumac Extract Works at Fredericksburg, Va. The plant will be enlarged and additional machinery installed.

Washington

TACOMA.—The Standard Chemical Company has leased 75 ft. of waterfront at Tacoma, Wash., to be used for manufacturing purposes and will double its present plant there. The officers of the company are Paul Van Horst, president; W. A. Lenenberger vice-president; W. C. Morrow, secretary, and J. E. Berkheimer, treasurer.

West Virginia

CHARLESTON.—The Roessler & Hasselacher Chemical Company of New York has purchased 175 acres of land, 14 miles from here, and will erect a \$1,000,000 plant.

Wisconsin

McDILL.—John Strange, of Neenah, plans the erection of a paper and pulp mill to manufacture Kraft paper.